DRAFT SUPPLEMENT
to the
ENVIRONMENTAL IMPACT STATEMENT

PROTOTYPE PROJECT TO AUGMENT SNOW PACK BY CLOUD SEEDING USING GROUND BASED DISPENSERS IN PLUMAS AND SIERRA COUNTIES

Plumas National Forest
Sate of California
Department of Water Resources

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ABSTRACT

The Department of Water Resources is proposing to conduct a 5-year operational test program for enhancing water yield by augmenting snow pack This will be accomplished by cloud seeding of winter storms using ground-based dispensers located on mountain tops in the vicinity of the Lakes Basin Area on the Plumas and Tahoe National Forests. This document is a Draft Supplement to the Prototype Project to Augment Snow Pack by Cloud Seeding Using Ground Based Generators. The Supplement is being issued in response to specific issues brought forth by the California Sportfishing Protection Alliance and the Friends of Plumas Wilderness in their appeal of the Final Environmental Impact Statement for this project.

Reviewers should provide the Forest Service with their comments during the review period of the Draft Supplement to the EIS. This will enable the Forest Service and the Department of Water Resources to analyze and respond to the comments at one time and to use the information acquired in the preparation of the Final Supplement to the EIS, thus avoiding undue delay in the decision making process. Reviewers have an obligation to structure their participation in the NEPA process so that it is meaningful and alerts the agency to the reviewer's position and contentions (Vermont Yankee Nuclear Power Corp. v. NRDC, 435 U.S. 519, 443 (1978)). Environmental objections that could have been raised at the draft stage may be waived if not raised until after completion of the final document (Wisconsin Heritages, Inc. v. Harris, 490 F. Supp. 1334, 1338 (E.D. Wis. 1980)). Comments on the Draft Supplement should be specific and should address the adequacy of the statement or the merits of the alternatives discussed (40 CFR 103.3).

Comments must be received by September 30, 1991. Comments should be addressed to Mr. Court Bennett, U. S. Forest Service, P. O. Box 11500, Quincy, CA 95971.

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I. PURPOSE AND NEED FOR ACTION

A. INTRODUCTION

This is a Draft Supplement to the Final Environmental Impact Statement completed for a 5-year prototype cloud seeding project proposed by the California Department of Water Resources. The Forest Supervisor's decision to authorize the cloud seeding project was appealed to the Forest Service's Pacific Southwest Regional Forester who affirmed all but five issues raised by the appellants. This document addresses these issues. The appellants were the California Sportfishing Protection Alliance and the Friends of Plumas Wilderness.

The proposed project would seed approximately 165,000 acres of the Upper Feather River Basin using a network of ground-based, remotely operated liquid propane dispensers (Figure 1). Propane is a freezing agent which vaporizes after being released as a liquid from the dispensers. Releases during cold winter storms would create ice crystals which grow to snowflakes. To assure this, the dispensers need to be placed at elevations having winter-time clouds that are at temperatures below freezing. It is anticipated that the total increased precipitation for the enhancement area would average less than 5%, and would primarily be in the form of snowfall. The expected increase in snowpack is well within the normal range of variation for precipitation for the area. Total augmented precipitation is expected to add about 32,000 acre-feet to the project watershed during an ideal cloud seeding season of near average, normal precipitation.

B. NATURE AND PURPOSE OF THE ACTION

The objective of this Draft Supplement to the EIS is to address the issues not affirmed by the Regional Forester. Once addressed, a determination needs to be made as to whether this added information will require further changes to the Final EIS issued in September of 1990. Issues not affirmed by the Regional Forester were:

1. The EIS did not adequately describe the existing known data that can relate to the watershed condition and fisheries habitat of the third order streams mentioned in the California Sportfishing Protection Alliance and the Friends of Plumas Wilderness appeal.

2. There was not an adequate description of the cumulative effects and the factors used in the cumulative watershed effects analysis on the third order drainages mentioned in the appeal.

3. The effects of the project on sensitive, threatened and endangered wildlife species need to be better addressed.

4. A further analysis needs to be made on the potential effects of flooding on small streams.

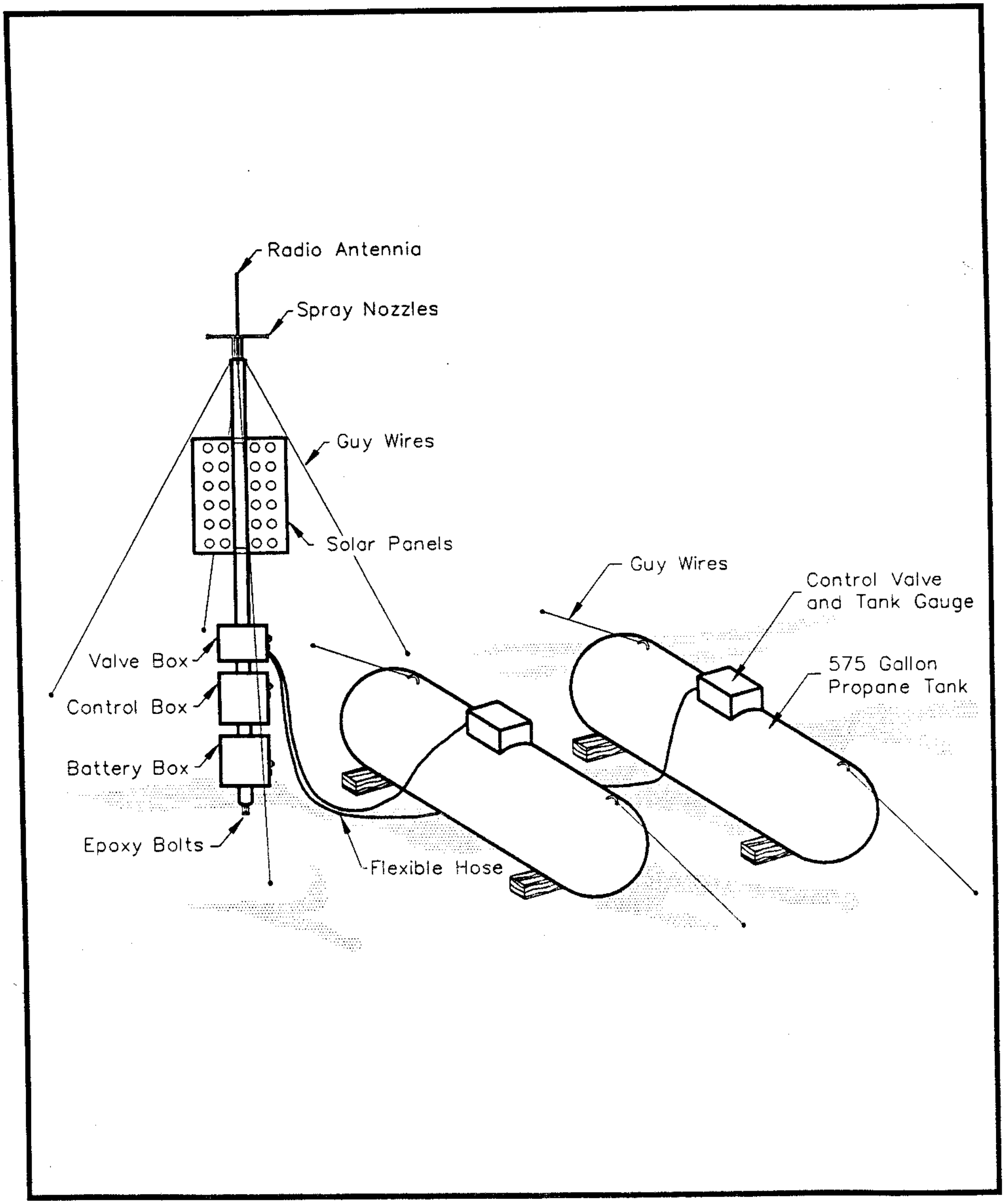


Figure 1. Sketch of Propane Seeding Dispenser Design and Site Set-Up.

5. Identify if there are any municipal supply watersheds within the project area, and, if so, the effects of the project on water quality in these watersheds.

6. Assure that the California Department of Fish and Game, and the U.S. Fish and Wildlife Service are consulted on this project.

II. ALTERNATIVES, INCLUDING THE PROPOSED ACTION

One of the objectives of this Draft Supplement is to determine whether additional alternatives need to be considered as a result of the analyses of the appeal issues. Based on these analyses, there is no basis for considering additional alternatives beyond those discussed in the Final EIS for this project.

III. AFFECTED ENVIRONMENT

The affected environment is described on pages 28 to 38 of the Final EIS for the Prototype Project to Augment Snowpack by Cloud Seeding Using Ground Based Dispensers in Plumas and Lassen Counties (September 1990). In this document, 10 propane dispenser sites are proposed to be located on mountain tops in Plumas and Sierra Counties. The proposed primary target area for this 5-year prototype enhancement project is defined by the dispenser locations forming a northwest to southeast alignment generally following the Sierra Nevada Crest from Pilot Peak to the higher elevations above Gold Lake (Figure 2). The effective primary enhancement area is located almost totally within the Middle Fork of the Feather River drainage. The area of impact includes the Middle Fork of the Feather River as it traverses the area from Portola on the east to below Sloat on the west. The major streams discharging to the Middle Fork in this stretch of the river are all of catchment areas of Willow, Frazier, Gray Eagle, Jamison, Long Valley and Popular Creeks. Due to the placement of the dispensers, three other streams will be partially impacted as their catchment areas are not entirely within the enhancement area relative to the tracks of the storms that can be seeded. These streams are the lower ends of Big Grizzly and Sulpher Creeks, and the upper catchment area of Nelson Creek, above the area designated as a wild trout stream.

Vegetation within the enhancement area includes ponderosa pine, sugar pine, douglas fir, red and white fir, incense fir, jeffrey pine, and oak woodlands. Other vegetation associations present are lodgepole pine, riparian deciduous, dry grasslands, pine-juniper woodlands, and wet meadows.

The communities of Sloat, Cromberg, Johnsville, Plumas-Eureka Estates, Mohawk, Blairsden, Delleker, Graegle, Clio, and Portola are located within the project boundaries. Elevations in the enhancement area range from 7,812 foot Mt. Elwell along the Sierra Nevada Crest to approximately the 4,000 foot level of the Middle Fork Feather River west of Sloat.

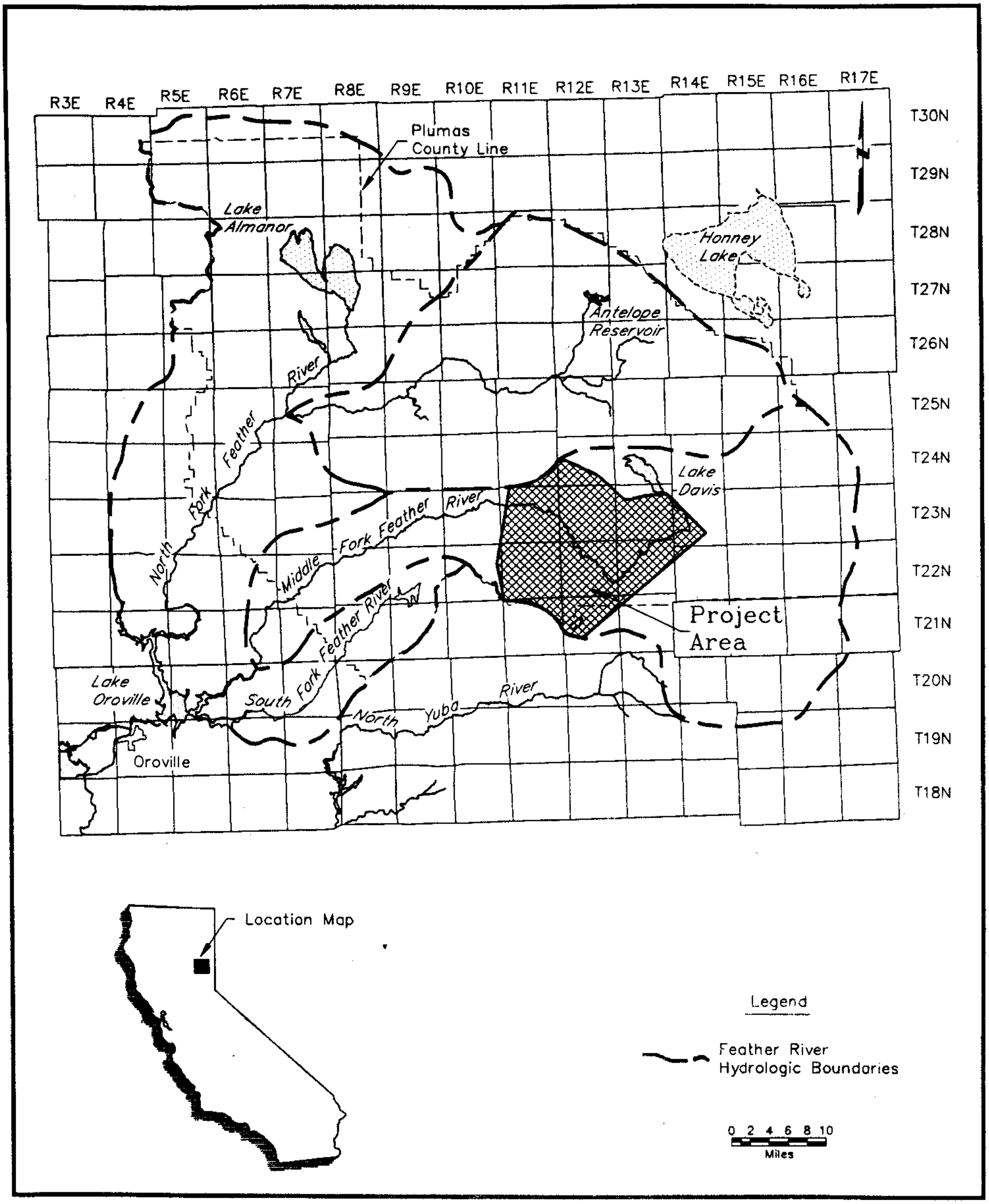


Figure 2. Location of Project Area for Snowpack Augmentation in Lake Oroville Catchment Area.

Mean monthly temperatures below freezing occur at Portola during the months of December and January. August, the warmest month, has an average daytime temperature of over 80° F. Portola, on the east side of the enhancement area, receives less than 20 inches of precipitation per year, which is significantly less than the westerly portion of the enhancement area which attains an annual average up to 60 inches per year.

IV. ENVIRONMENTAL ISSUES

ISSUE 1. The EIS did not adequately describe the existing known data that can relate to the watershed condition and fisheries habitat of the third order streams mentioned in the California Sportfishing Protection Alliance and the Friends of Plumas Wilderness appeal. (Appeal Item 3b).

ISSUE 2. There was not an adequate description of the cumulative effects and the factors used in the cumulative watershed effects analysis on the third order drainages mentioned in the appeal. (Appeal Item 8b).

DIRECTION

Review the information provided, gathering landslide, channel, soils and fisheries data that are known to exist for the area and re-evaluate the effects of early snow melt on landslide and channel stability and fisheries resources.

Supplement the EIS with a cumulative watershed analysis on streams. It is important to know if any watersheds are over threshold, and if the incremental effect added by this project will adversely effect stream channel stability, landslides, bank failures, channel aggradation or degradation, or fish habitat. For watersheds that are over threshold, identify sensitive areas for watershed improvement and mitigation measures which would bring the watersheds to within the threshold of concern.

SUMMARY OF FINDINGS

Many of the watersheds within the project area have been heavily impacted. These watersheds can develop significant problems in the future unless the current trend is reversed. These problems are not expected to be measurably increased, if at all, by the proposed cloud seeding project. Effects from the addition of the proposed cloud seeding program to the project area were determined to be negligible for the following reasons: 1) no change in ERA values, 2) no detectable adverse impacts, 3) cloud seeding will only occur in years of average or below average precipitation, 4) cloud seeding will only occur when precipitation is in the form of snow at or below 5,000 feet elevation, and 5) the use of stringent suspension criteria.

No adverse impacts to either instream or downstream beneficial uses were identified. The proposed project should yield significant benefits to both instream and downstream beneficial uses.

DISCUSSION

The Plumas National Forest Land and Resource Management Plan (USFS 1988) directs that watersheds be protected from the effects of cumulative impacts. In compliance with this direction, cumulative watershed effects (CWE) analyses were conducted to determine if the effects of the proposed prototype snow augmentation project could contribute to the cumulative effects found in watersheds within the project area. The watersheds selected for CWE analyses were identified in the Regional Forester's Special Use Permit Appeal Decision, and include Jamison Creek, Poplar Creek, Nelson Creek, Graeagle Creek, Sulphur Creek, Willow Creek, Consignee Creek, Long Valley Creek, Jackson Creek, Rattlesnake Creek, Little Long Valley Creek, Greenhorn Creek, Estray Creek and Squirrel Creek watersheds. Staffs from the Plumas National Forest and Department of Water Resources agree with the appellants that the watersheds identified in the Regional Forester's Decision represent the most sensitive and or degraded watersheds within the project area.

These CWE analyses were conducted by Department of Water Resources personnel in cooperation with the U.S. Forest Service and follow the general format set forth in the Forest Service Handbook Section 2509.22. This method uses "equivalent roaded acres" (ERA) to serve as an index to measure the impact of past, present and future land management activities on downstream water quality and beneficial uses. This method of CWE analysis is comprised of three distinct steps. First, the amount of sensitive ground within a watershed is quantified based on the watersheds physical characteristics including climate, topography, slope, stream channel geomorphology, channel gradient, stream channel hydrology, soils, geology, elevation and physically and biologically sensitive land units. Second, the type, intensity, and chronology of management activities are collected and analyzed using the ERA methodology (Seidelman 1981). Third, a threshold of concern (TOC) is defined based on the relative natural sensitivity of the watershed. The existing or future ERA values are compared with TOC values to predict the risk of initiating cumulative effects.

Cumulative effects are defined as effects on the environment which result from the incremental impact of the action when added to other past, present and reasonably foreseeable future actions regardless of what agency or person undertakes such other actions. Cumulative effects can be singularly minor, but collectively significant actions which occur over a period of time.

The National Environmental Policy Act (NEPA) and Federal Clean Water Act (FCWA) mandate the assessment of cumulative effects of proposed projects.

Current ERA values, developed from recent CWE analyses, exist for Little Long Valley Creek, Rattlesnake Creek, Jackson Creek, Long Valley Creek, and Consignee

Creek. This CWE analysis will, therefore, concentrate on those watersheds where current ERA values do not exist, including Jamison Creek, Poplar Creek, Nelson Creek, Graeagle Creek, Sulphur Creek, Willow Creek, Greenhorn Creek, Estray Creek, and Squirrel Creek.

Beneficial Uses of Water

The beneficial uses of water within the project area include cold water fish habitat, recreation, municipal, domestic and agricultural water supply and wildlife habitat. Additional downstream beneficial uses include warm water fish habitat, power generation, industrial use and reservoir storage for later agricultural and domestic uses.

The proposed snow augmentation project is designed to increase water yields for instream and downstream beneficial uses. The purpose of these CWE analyses are to determine where adverse cumulative effects associated with increased water yields to beneficial uses may exist and, if they exist, to quantify the relative magnitude of those adverse effects.

Water Quality Protection Criteria

To protect beneficial uses during the prototype snow augmentation project, suspension criteria have been developed. These criteria include: 1) suspension of all cloud seeding when the water content of the snowpack in the Feather River Basin, as measured at 25 snow courses in the basin, exceed the average historic April 1 total amounts by the following percentages: January 1 - 110 percent, February 1 - 130 percent, March 1 - 150 percent and April 1 - 160 percent; 2) suspension of all cloud seeding when quantitative precipitation forecasts issued by the National Weather Service indicate the potential for excessive runoff in the project area or downstream areas, as determined by the Flood Forecasting staff of the Department of Water Resources. These include forecasts of precipitation events at Quincy which exceeded 4 inches in 24 hours, 5 inches in 48 hours, or 6 inches in 72 hours; or (for backup) when the gauge amount at LaPorte is observed or predicted to exceed 5 inches in 24 hours, 6 inches in 48 hours, or 7 inches in 72 hours. The recurrence interval of precipitation events of this magnitude are 2.5 and 2.0 years respectively; 3) whenever an inflow of 60,000 cubic feet per second (cfs) or more into Oroville Reservoir is predicted or observed. The recurrence interval of this magnitude of inflow is approximately 2.0 years; 4) whenever Oroville Reservoir flood control space is encroached and significant releases (>20,000 cfs) are being made at Oroville Dam; 5) whenever flood flows or stages are occurring, or are forecast to occur, which exceed flood warning stages on the Feather River below Oroville; and 6) whenever the National Weather Service has issued a flash-flood warning for the project area or the DWR Project Director predicts conditions so hazardous as to warrant suspension of cloud seeding conditions including avalanche warnings.

The EIS states that the prototype snow augmentation project is designed to operate primarily in years of average or below average precipitation. Cloud seeding will only occur when temperatures at the propane dispenser sites are less than -2.0° C (28.3° F) and precipitation falling at 5,000 feet or below is in the form of snow. These seeding and previously mentioned suspension criteria are designed to reduce or eliminate the risk of landsliding, avalanche, flooding, erosion, sedimentation and channel degradation problems created by the project and to maintain or improve water quality, fisheries habitat and other beneficial uses.

Watershed Size

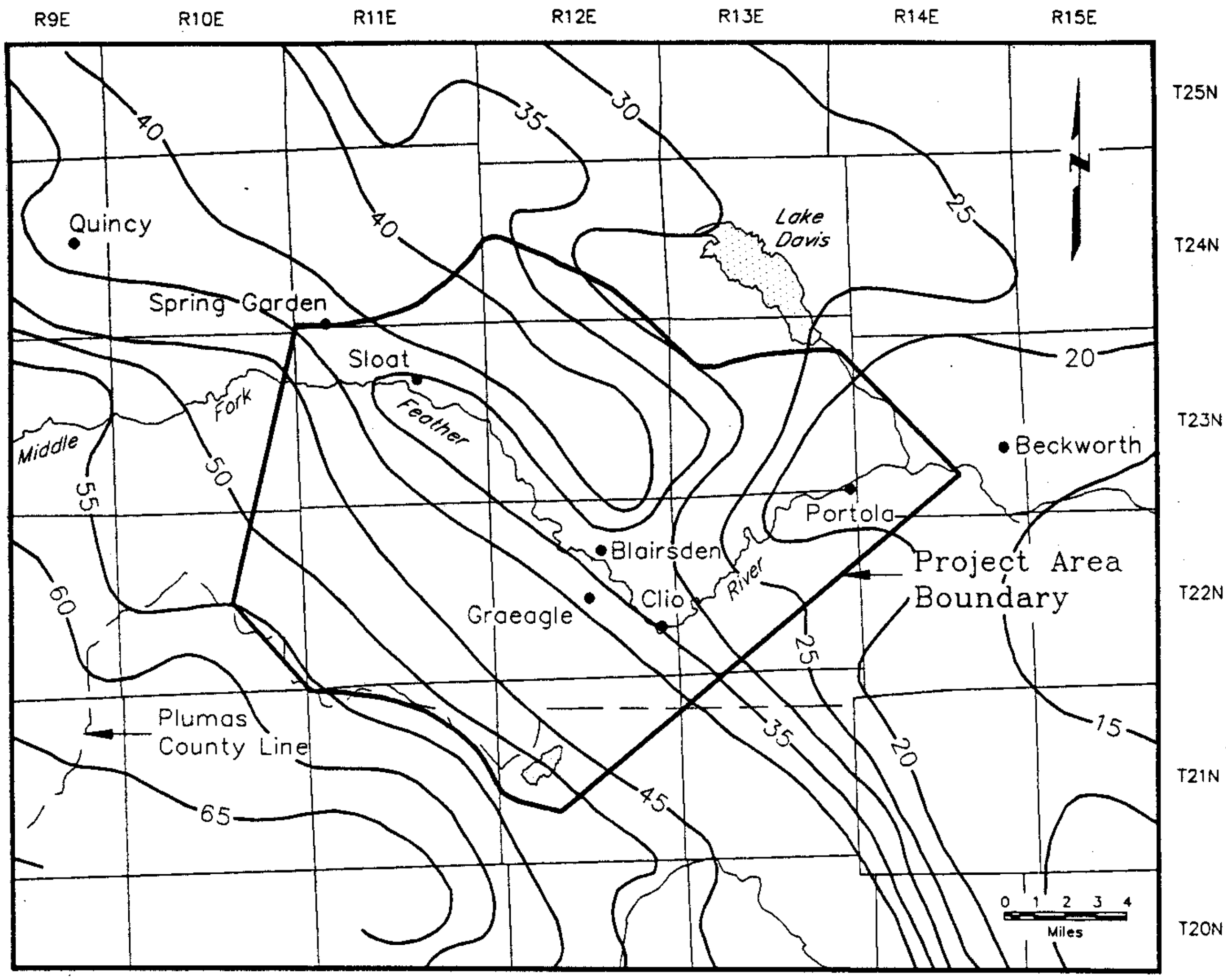
The project area, comprising approximately 165,000 acres, was delineated into a number of subwatersheds, averaging about 10,370 acres in size. These are larger than the size normally evaluated for CWE by the Plumas National Forest to determine the impacts of timber harvesting. Third order size watersheds are normally evaluated in order to best detect CWE impacts caused by the site-specific impacts. Because the effects of cloud seeding are widespread and the mechanisms that may cause CWE to occur from cloud seeding work over large watershed areas, larger subwatersheds were chosen for the analyses. The selected subwatersheds also best delineate the project area into logical units.

Due to the size of the project area, the beneficial uses of water resources and watershed characteristics present, third and fourth order size watersheds were selected for CWE analyses. We recognize that in analyses of watersheds of this size, the ability to evaluate the effects of distribution of activities are reduced. For example, clumping of land use activities in a small subwatershed may produce conditions which exceed TOC for that subwatershed, but the watershed as a whole may be well below TOC. In larger watersheds, it was necessary to reduce TOC levels to compensate for the "dilution" of impacts by a large area.

Watershed Characteristics

The project area lies within the Sierra Nevada Geologic Province. The geology of this province is very complex, consisting of alluvial deposits (Quaternary age), volcanic rocks (Cenozoic age), granitic rocks (Mesozoic age) and weakly metamorphosed sedimentary and volcanic rocks (Paleozoic and Mesozoic age). Geologic structure of the project area is highly complex due to extensive faulting and folding, erosion, deposition of sediments, igneous intrusive activity and volcanic activity. The geology largely defines the project area's physical topography, soil structure and erodibility, stream and hillslope hydrology, stream and hillslope geomorphology, and slope stability. Discussion of each of these watershed attributes and their response to land use follows.

Precipitation within the project area occurs mostly in the form of snow, and averages range from a high of over 60 inches per year along the south project boundary to less than 20 inches per year near Beckwourth (Figure 3). Precipitation occurs primarily from October through April with cold wet winters and dry, warm



(DWR 1966)

Figure 3. Lines of Equal Precipitation in Project Area (In Inches).

summers. Snowpack of 5 to 10 feet, or more, frequently occurs during the winter above 5,000 to 6,000 feet elevation. Land disturbance activities in areas of low annual precipitation require longer recovery periods due to the relative slowness of vegetative recovery. High elevation sites within the project also exhibit longer recovery periods due to the shorter growing season of vegetation. Intense summer thunderstorms occur occasionally and have been documented to be a significant factor in erosion and sediment production. The effects of these storms are localized and more pronounced on the areas of low annual precipitation.

Climatic regime (broadly defined as zones dominated by precipitation in the form of snow, rain on snow, or rain) is the key climatic factor in this CWE analysis. The project area was selected due to the high percent of snow dominated zone relative to rain dominated zone (Figure 4). The project's influence on each of these zones was identified during the environmental review process as an area of significant public interest.

The physical topography of the project area is steep mountainous terrain with a small number of alluvial valleys. Elevations range from over 7,500 feet on the north and south project boundaries to less than 4,000 feet near Spring Garden.

Slopes greater than 60 percent occur throughout the project area (Figure 5), and, of those, many are at risk of landsliding and surface erosion. Less than two percent of Willow Creek, Squirrel Creek, Estray Creek, Sulphur Creek and Graeagle Creek watersheds contain slopes greater than 60 percent. Jamison Creek, Poplar Creek and Greenhorn Creek watersheds contain between two and four percent of their area in slopes greater than 60 percent. Nelson Creek contains nearly 10 percent of its area in slopes greater than 60 percent. The project area is not considered steep compared to most watersheds in the Sierra Nevada Mountains, but enough steep areas exist to make slope instability a consideration.

Inner gorge zones are a geomorphic feature consisting of oversteepened slopes (herein defined as 60 percent or greater) adjacent to a stream channel. Debris slides and rockfalls naturally occur in these sensitive zones, affecting channel stability and downstream sedimentation. Willow Creek, Estray Creek and Squirrel Creek watersheds contain no inner gorge features (Figure 6). The percent area of inner gorge zone features is highest in the Nelson Creek watershed at 2.5 percent. Except for within Nelson Creek, inner gorge features are not a major concern.

Landslides, both active and inactive exist throughout the project area, but in relatively low numbers and sizes. Landslides can result in channel changes through aggradation and degradation processes. Landsliding can deflect stream channels and produce additional changes through scouring or trigger additional landslides by deflecting stream flows against opposite slopes. The Graeagle Creek watershed contains no known landslide features (Figure 7). Watersheds with less than one percent of their area in landslide features include Willow Creek, Poplar Creek,

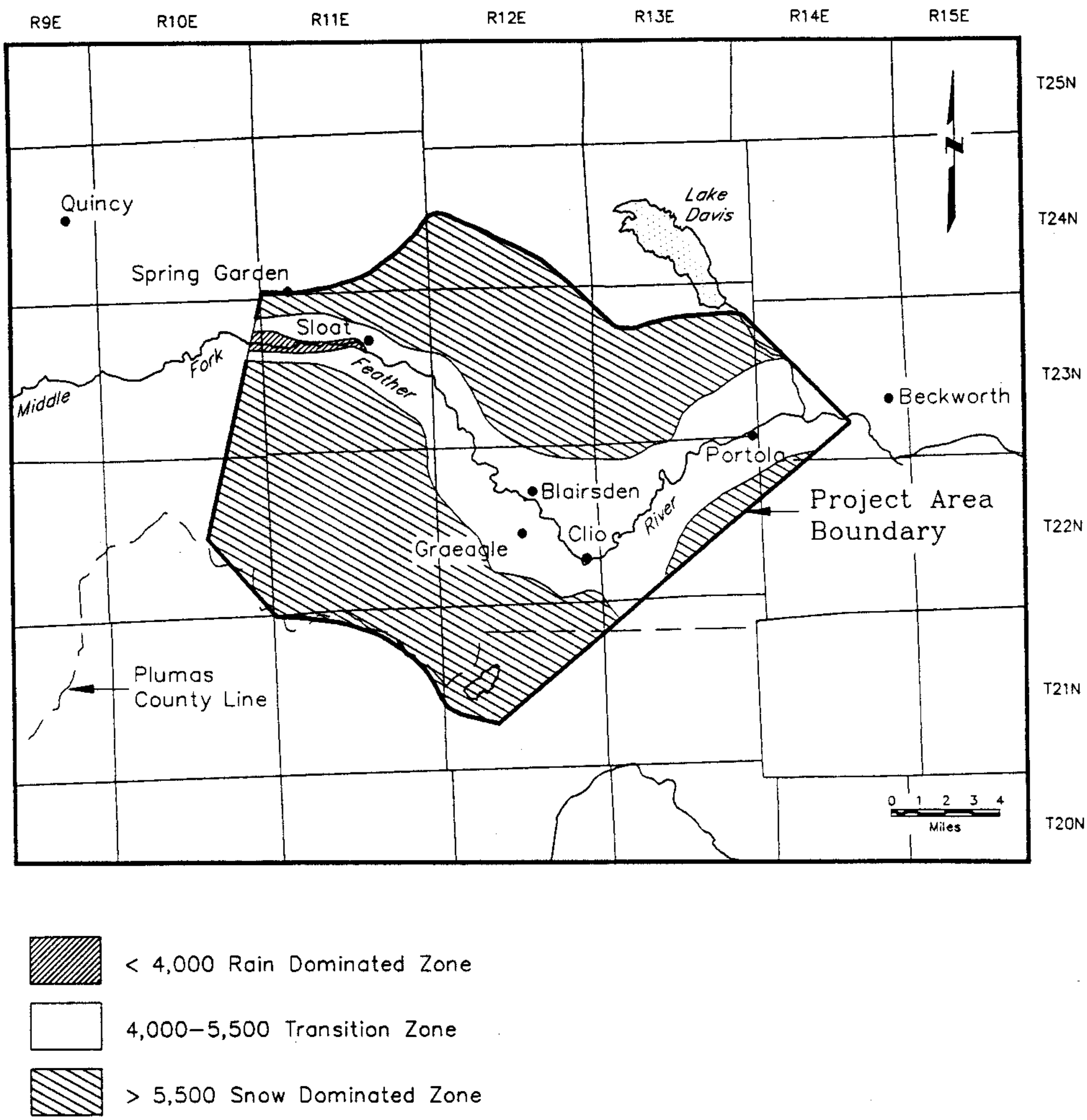


Figure 4. Approximate Locations of Climatic Zones in the Project Area.

Figure 5. Percent area of each watershed containing slopes over 60%.

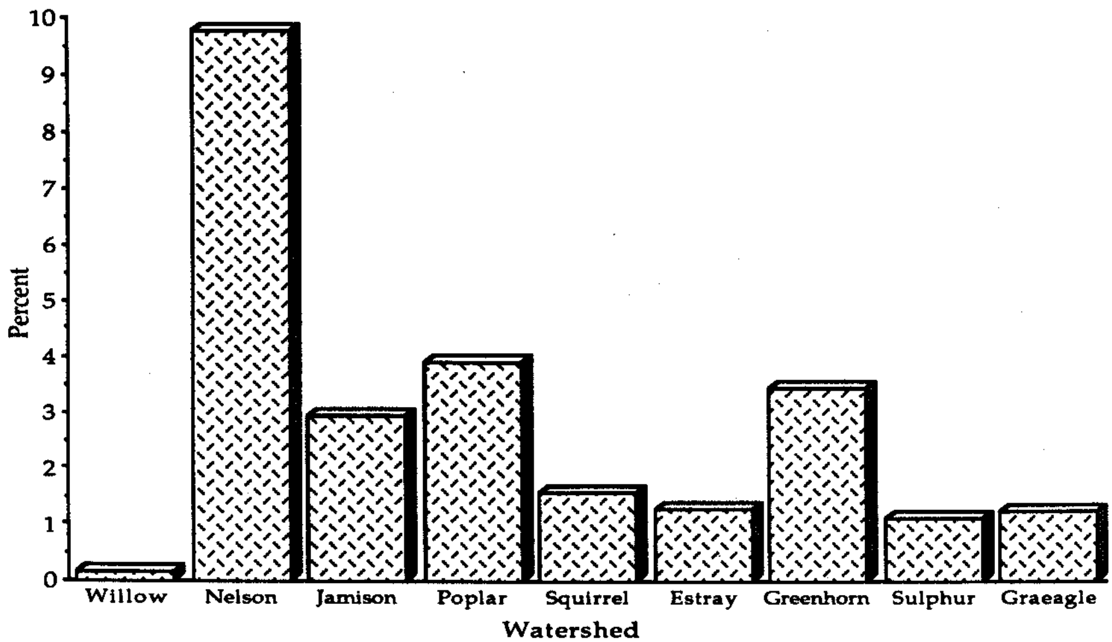


Figure 6. Percent area of each watershed classified as inner gorge zone.

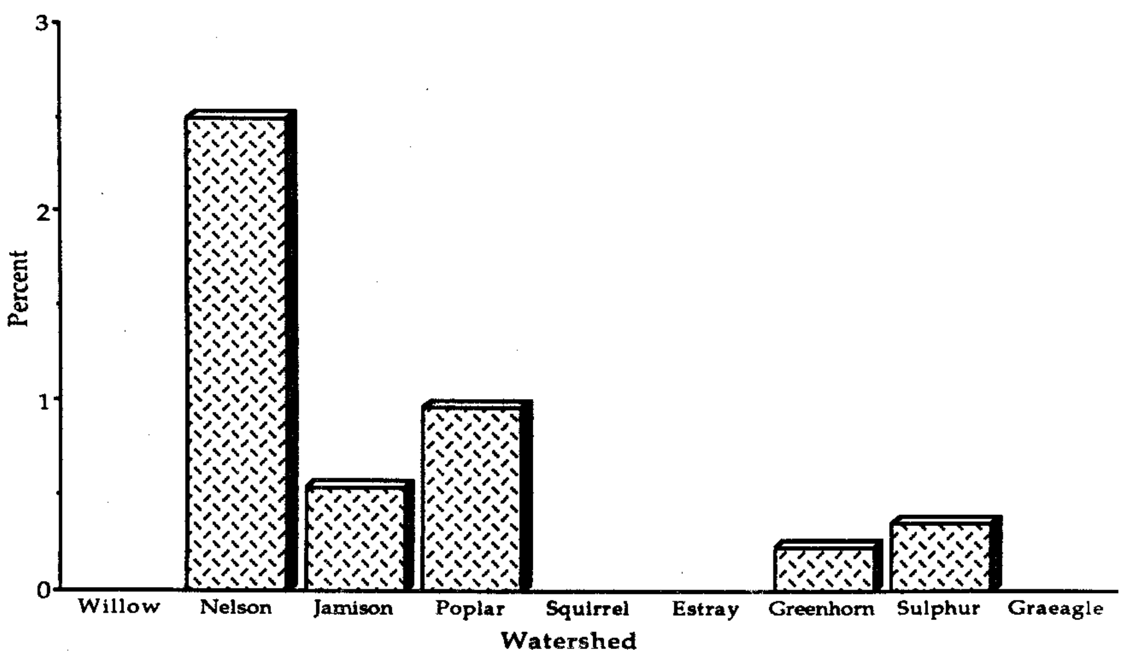
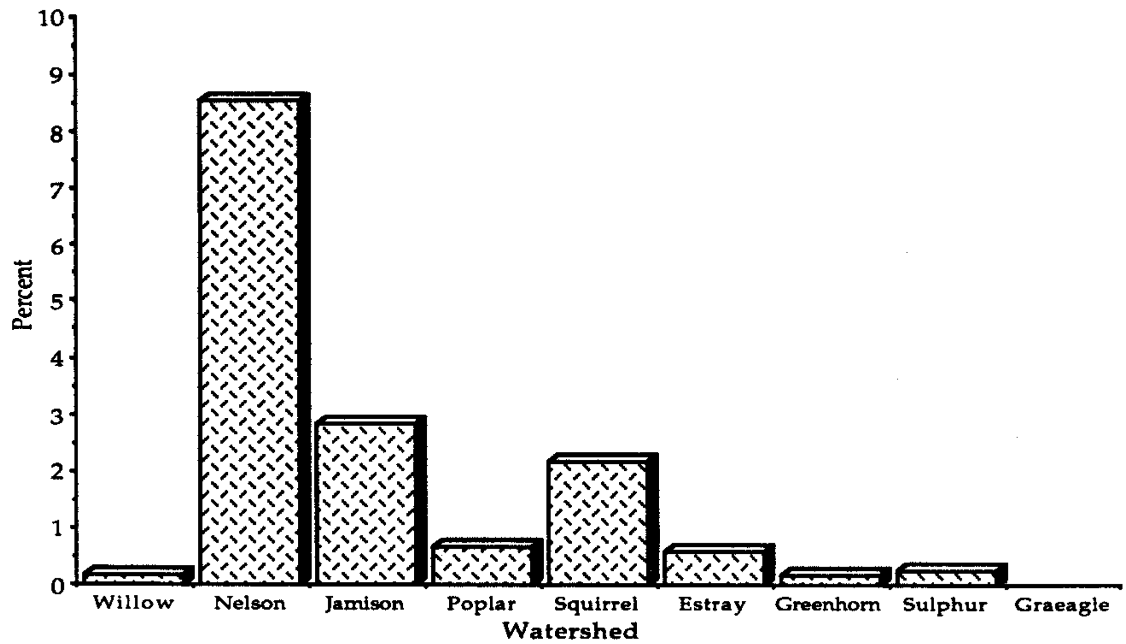


Figure 7. Percent area of each watershed classified in a landslide condition.



Estray Creek, Greenhorn Creek, Sulphur Creek, and Graeagle Creek. Squirrel and Jamison Creek watersheds each contain between two and three percent of their area in landslide features. Over 8.5 percent of the Nelson Creek watershed is occupied by landslides. Landslides are classified as active or inactive. Although active landslides are most likely to be affected by land disturbance or changes in precipitation, it is possible to reactivate inactive landslides.

The variation of geologic parent material, slope, aspect and climate have produced a diversity of soils within the project area. Soils in the western portion of the project area are generally deeper and more productive than eastside soils. Soils on northern exposures are generally deeper, moister and more productive than soils on southern exposures. Soils having high to very high erosion potentials are present in every watershed within the project area (Figure 8). The Graeagle Creek watershed contains the highest percentage (63 percent) of soils classified high to very high erosion potential. Willow Creek contains the lowest percent of soils in the high to very high soil erosion potential classes at 2.5 percent. Highly and very highly erosive soils can be adversely effected by land use activities through soil compaction and exposure to erosional mechanisms.

Riparian areas (including off-channel wetlands) are biologically and physically important and sensitive land units. Riparian areas (which frequently occur on alluvial deposits) are sensitive to land use activities because their soils are very highly erosive, which can lead to gullying, increased peak flows, and lost habitats. The percentage of each watershed classified as riparian ranges from 2 percent on the

Willow Creek watershed to 5.7 percent on the Nelson Creek watershed (Figure 9).

Figure 8. Percent of soils with high to very high erosion potential in each watershed.

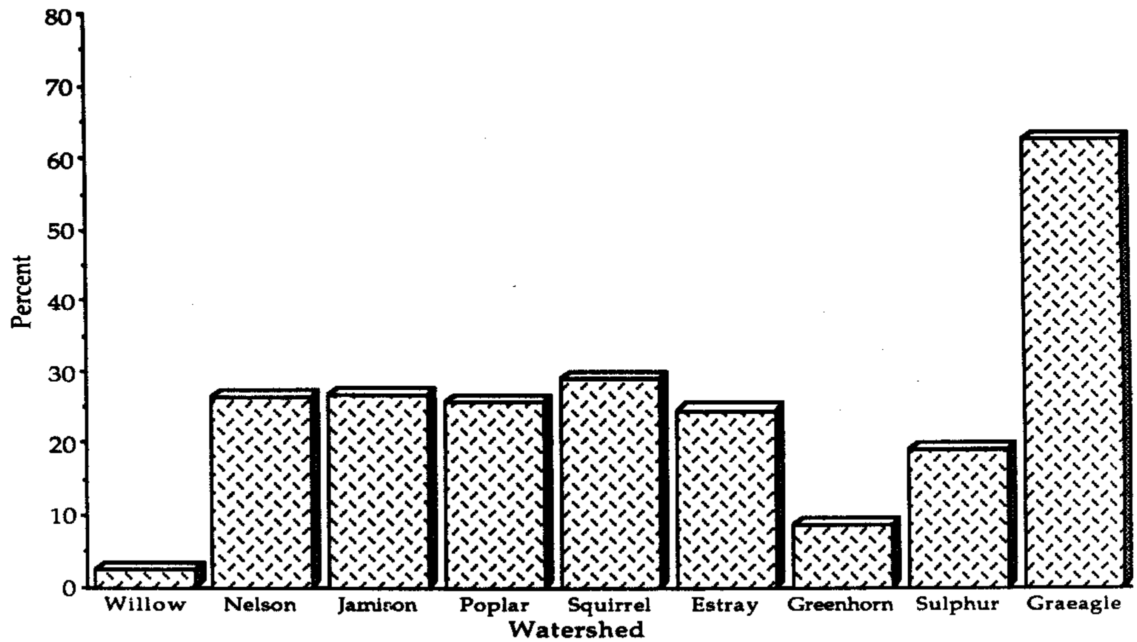
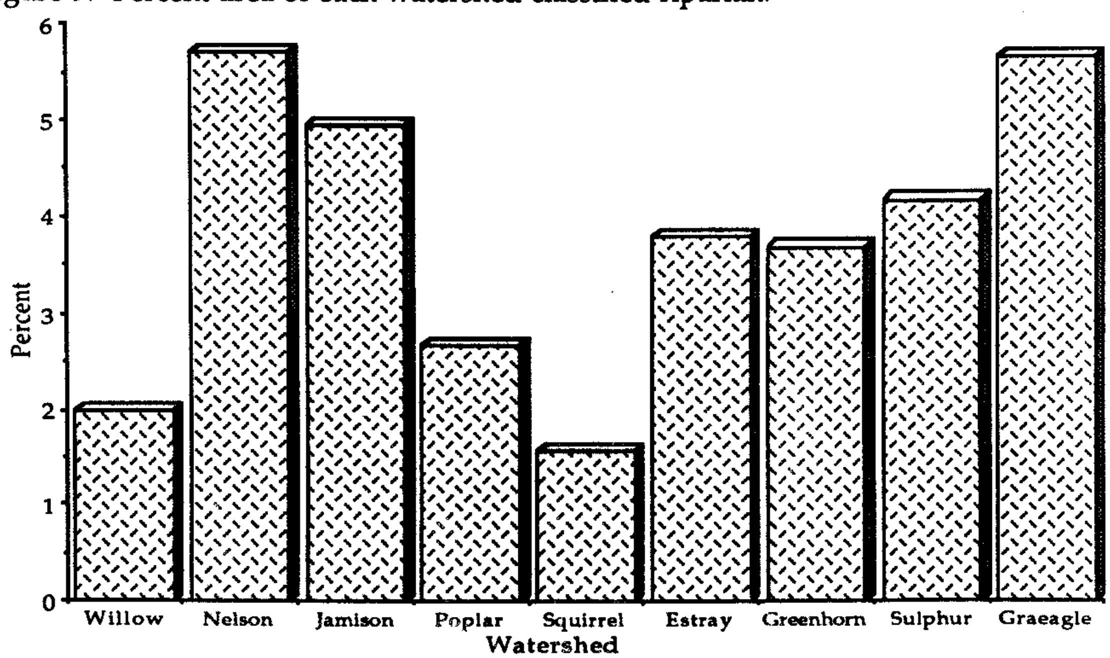


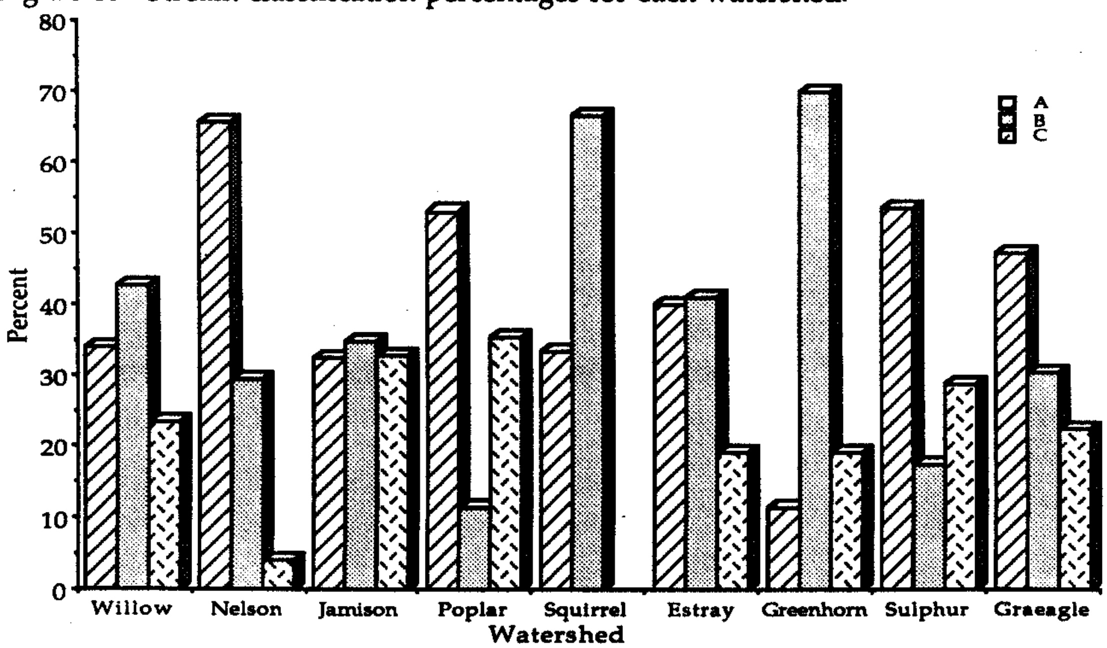
Figure 9. Percent area of each watershed classified riparian.



Streams present in the project area are classified "A", "B" or "C". This classification is based on the morphological criteria of gradient, width to depth ratio, sinuosity, channel materials, channel confinement, entrenchment, soils, and land form (Rosgen 1985). "A" type streams are steep, with very deep, well defined, confined channels, water slopes (gradients) of 4 to 10 percent, and width to depth ratios of 10 or less. "B" type streams are generally of moderate gradient, moderate to well confined channels, moderately to deeply entrenched channels with gradients of 1.5 to 4.0, and highly variable width to depth ratios (0.1 to 25). "C" type stream channels have low gradients, are unconfined with moderate to shallow channel entrenchment and width to depth ratios generally less than 10.

"A" type stream channels are present in every watershed and exhibit rapid response to major storm events. These stream channels are sensitive to landsliding. "A" type stream channels are major sources of sediment to "B" and "C" type stream channels. Nelson Creek, Poplar Creek, and Sulphur Creek watersheds contain over 50 percent of their total stream miles in "A" type stream channels (Figure 10). "B" type stream channels are sensitive to flooding and channel scouring during very high flows and loss of riparian vegetation. Greenhorn Creek and Squirrel Creek watersheds contain a relatively high percent (>65%) of "B" type channels. "C" type stream channels are generally the least common in the project area and are associated with meadows, such as those found in Sulphur Creek. "C" type stream channels are highly sensitive to erosion and channel degradation resulting from increased peak flows and loss of riparian vegetation. Jamison Creek and Poplar Creek watersheds contained the highest percent of stream channels classified as "C" type.

Figure 10. Stream classification percentages for each watershed.



Mechanisms for Initiating CWE's

Total ground disturbance related to installation of precipitation gauging stations, propane dispensers and propane tank storage are less than one acre. The proposed prototype snow augmentation project will not alter present or future ERA values. No roading or other forms of ground disturbance (other than the one acre mentioned above) will occur.

The project is designed to increase precipitation during years of average to below average precipitation. Approximately 2/3 of the water produced is predicted to leave the project area as runoff while the remaining 1/3 is expected to be taken up by ground water recharge and vegetative transpiration. The availability of increased soil water during years of below average precipitation is expected to reduce plant stress and possibly increase growth rates. These changes could reduce drought and insect losses of commercial timber, thus reducing the extent of salvage logging. Other secondary benefits include accelerated recovery of vegetation on disturbed sites, possible wildfire reduction, a slight increase in the amount of time stream flows are up, and increased summer flows, thereby enhancing the fishery.

We expect the secondary effects of the project to be largely beneficial. However, the magnitude of this benefit remains unquantified and probably undetectable.

Monitoring of other cloud seeding projects (Kattleman 1986) indicates that the adverse watershed effects of snow augmentation, assuming a 10 percent increase in snow-water content over a 6 to 7 month period, are probably undetectable. The suspension criteria employed is expected to further reduce the occurrence of adverse impacts. For the following reasons the cumulative effects of this cloud seeding program were judged in the EIS to be negligible: 1) no changes in ERA values; 2) no detectable adverse impacts; and 3) the use of very stringent suspension criteria.

The primary mechanism that could initiate CWE's is not expected to occur under normally prescribed operations. This analysis looked at a "worst case" development. Fifteen and 50-year rain on snow events were projected with and without the project. The probability of a 15-year rain on snow event occurring within a given year of the five year prototype project is 1 in 15, or 7 percent. The potential mechanisms for initiating CWE during major rain on snow events were identified through an interdisciplinary scoping session and include: 1) increased peak flows due to rapid snowmelt, and 2) increased risk of landsliding from increased peak flows eroding the toes of landslide prone areas or from increased soil saturation weakening landslide prone areas.

Watershed History

Land use impacts increased significantly beginning in the 1850s. Early land use impacts were generally related to mining activities. Small seasonal communities surrounding placer mining areas occurred along Nelson Creek, Poplar Creek, Jamison Creek, Squirrel Creek, Graeagle Creek and along the Middle Fork Feather River. Early placer mining impacts were generally limited to in-channel disturbances. Subsequent hydraulic mining involved water diversion and rechannelization causing massive erosion and sedimentation. Booming (a form of hydraulic mining where upstream water sources were diverted over a slope to erode mineral bearing materials) was common in the Poplar Creek drainage. Small permanent communities (5 to 6 individuals or families) were established near hydraulic mining operations. Larger permanent communities developed adjacent to hard rock mining operations in the Eureka and Chris Peaks areas. Hard rock mining required massive amounts of timber (10 acres of mature forest per mile of mine) for mine supports, steam power to run equipment and pump water, and housing. Slopes adjacent to hard rock mines were clearcut.

Historical accounts indicate that during the 1850s the project area contained open stands of mature pine with an herbaceous understory. The majority of the project area was intensively grazed by sheep and to a lesser extent by cattle in the late 1800's. Low intensity wildfires were common and served to maintain the open pine stands. Intensive grazing has continued to decrease as a land use activity in the project area since the 1930s, primarily due to degraded pasture lands and improvements in grazing strategies.

Localized intensive timber harvesting in support of mining activities continued until 1910. During 1910, the Western Pacific Railroad was completed through the project area and large scale logging commenced. Railroad logging (involving clear cutting within 1/4 to 1/2 mile of railroad spurs) occurred in the Squirrel Creek watershed. A grease chute for transporting timber to the railroad was established in the Greenhorn and Estray Creek watersheds. The scars from this chute are still visible today.

Massive destructive wildfires became increasingly common during the 1930s and 1940s. Succession brushfields and logging slash fueled these wildfires.

Historical records indicate that the effects of these large scale land use impacts were severe as early as 1856 when an American Valley farmer reported fish kills and sediment covering his fields.

Recovery from approximately 80 years of resource exploitation is occurring. However, forest ecology and watershed characteristics have been altered to a less stable condition which is far more sensitive to current land use activities than those believed to have existed prior to 1850.

Roading for timber harvest purposes began in the late 1800s and continues today. Roads currently represent the single greatest land use impact to watershed stability and water quality degradation.

More recent land use changes include increased rural subdivisions and reduced average ranch size. Subdivision development within the project area began during the 1960s and continues today. Subdivision and housing development activity within the project area has been greatest in the Graeagle Creek watershed.

Natural Watershed Sensitivity

Natural watershed sensitivity is an estimate of a watershed's natural ability to absorb land use impacts. Generally, natural sensitivity to land use increases as the percentage of sensitive areas in the watershed increases. However, even sensitive land units do not contribute equally to a watershed's sensitivity.

To estimate each watersheds natural sensitivity to the proposed cloud seeding program, the prime indicators of natural sensitivity were compiled into sensitivity matrices (Tables 1 through 9). Each factor was weighted to reflect its contribution to watershed sensitivity.

Sensitivity analyses weights were assigned independently by three U. S. Forest Service hydrologists and one Environmental Specialist from the Department of Water Resources. The rationale for factor weights and changes in the matrix were submitted by each rater. The following discussion summarizes the rationale for factor weights and changes to the matrix.

The "erosion hazard rating" (EHR) factor was rated moderate (5), because the project is unlikely to affect rainfall intensity. Surface erosion is usually influenced by precipitation events with high intensities. Erosion studies conducted on the East Branch North Fork Feather River reveal that surface erosion (on undisturbed sites) is an insignificant source of stream sedimentation (SCS 1988).

The "percentage of stream miles classified as "B" or "C" type" received a moderate (5) rating. "B" and "C" type channels contain alluvial material which is very highly erosive when their vegetative cover is degraded. This factor is primarily important to provide perspective on the percentage of stream types "B" or "C" in degraded condition factor. For example, if 95 percent of the "B" and "C" type channels in a watershed are in a degraded condition, it is important to know whether "B" and "C" stream type channels comprise 5 or 100 percent of the watershed.

The "percentage of stream channels classified as "B" and "C" types in a degraded condition" factor was rated as important (9) due to their sensitivity to increased peak flows. This and the above factor can indicate channel sensitivity when these channel areas are gullied. This factor can directly impact water quality and fisheries habitat.

The "percentage of the watershed classified as riparian" factor was rated low (2). This factor is used as an indicator of alluvial material located in the stream channel. The presence of alluvial material in the stream channel is not in itself an indicator of erosion or sedimentation problems. However, should the stream channel

Table 1. Watershed sensitivity rating for Squirrel Creek

WATERSHED SENSITIVITY FACTOR	FACTOR WEIGHT (1-10)	Low 0	• • • • • 1	• • • • • 2	High 3	SCORE	WEIGHTED SCORE
Percent of watershed having HIGH to very HIGH EHR	5	< 10%	10%-20%	21%-40%	> 40%	2	10
Percent of stream miles in stream types B and C	5	< 10%	10%-25%	26%-50%	> 50%	3	15
Percent of all B and C type streams in DEGRADED condition	9	< 5%	5%-15%	16%-25%	> 25%	3	27
Percent of watershed classified as RIPARIAN	2	< 1%	1.1%-3.0%	3.1%-5.0%	> 5.0%	1	2
Percent of watershed classified as INNER GORGE ZONE	6	0%	0.1%-2.0%	2.1%-4.0%	> 4.0%	0	0
Percent of watershed over 60 % slope	5	< 5%	6%-10%	11%-20%	> 20%	0	0
Percent of area occupied by landslides	10	0%	0.1%-3.0%	3.1%-9.0%	> 9.0%	2	20
Mean elevation	5	> 6000'	5500-6000'	5000-5500'	<5000'	2	10
Mean annual precipitation	4	> 20"	21"-34"	35"-49"	>50"	2	8
TOTALS	52						92

AVERAGE RATING = (SUM OF WEIGHTED SCORES)/(SUM OF FACTOR WEIGHTS) = 1.77

DESCRIPTIVE RATING = MODERATE

Low	0.0-0.6
Low/Moderate	0.7-1.2
Moderate	1.3-1.8
Moderate/High	1.9-2.4
High	2.5-3.0

Table 2. Watershed sensitity rating for Greenhorn Creek

WATERSHED SENSITIVITY FACTOR	FACTOR WEIGHT (1-10)	Low 0	• • • • • 1	• • • • • 2	High 3	SCORE	WEIGHTED SCORE
Percent of watershed having HIGH to VERY HIGH EHR	5	$\boxed{< 10\%}$	10%-20%	21%-40%	> 40%	0	0
Percent of stream miles in stream types B and C	5	< 10%	10%-25%	26%-50%	$\boxed{> 50\%}$	3	15
Percent of all B and C type streams in DEGRADED condition	9	$\boxed{< 5\%}$	5%-15%	16%-25%	> 25%	0	0
Percent of watershed classified as RIPARIAN	2	< 1%	1.1%-3.0%	$\boxed{3.1\%\text{-}5.0\%}$	> 5.0%	2	4
Percent of watershed classified as INNER GORGE ZONE	6	0%	$\boxed{0.1\%\text{-}2.0\%}$	2.1%-4.0%	> 4.0%	1	6
Percent of watershed over 60 % slope	5	< 5%	6%-10%	11%-20%	$\boxed{> 20\%}$	3	15
Percent of area occupied by landslides	10	0%	$\boxed{0.1\%\text{-}3.0\%}$	3.1%-9.0%	> 9.0%	1	10
Mean elevation	5	> 6000'	5500-6000'	$\boxed{5000\text{-}5500'}$	<5000'	2	10
Mean annual precipitation	4	> 20"	21"-34"	$\boxed{35''\text{-}49''}$	>50"	2	8
TOTALS	52						68

AVERAGE RATING = (SUM OF WEIGHTED SCORES)/(SUM OF FACTOR WEIGHTS) = 1.30

DESCRIPTIVE RATING = MODERATE

Low	0.0-0.6
Low/Moderate	0.7-1.2
Moderate	1.3-1.8
Moderate/High	1.9-2.4
High	2.5-3.0

Table 3. Watershed sensitivity rating for Estray Creek

WATERSHED SENSITIVITY FACTOR	FACTOR WEIGHT (1-10)	Low 0	• • • • • 1	• • • • • 2	High 3	SCORE	WEIGHTED SCORE
Percent of watershed having HIGH to VERY HIGH EHR	5	< 10%	10%-20%	21%-40%	> 40%	2	10
Percent of stream miles in stream types B and C	5	< 10%	10%-25%	26%-50%	> 50%	3	15
Percent of all B and C type streams in DEGRADED condition	9	< 5%	5%-15%	16%-25%	> 25%	3	27
Percent of watershed classified as RIPARIAN	2	< 1%	1.1%-3.0%	3.1%-5.0%	> 5.0%	2	4
Percent of watershed classified as INNER GORGE ZONE	6	0%	0.1%-2.0%	2.1%-4.0%	> 4.0%	0	0
Percent of watershed over 60 % slope	5	< 5%	6%-10%	11%-20%	> 20%	0	0
Percent of area occupied by landslides	10	0%	0.1%-3.0%	3.1%-9.0%	> 9.0%	1	10
Mean elevation	5	> 6000'	5500-6000'	5000-5500'	<5000'	2	10
Mean annual precipitation	4	> 20"	21"-34"	35"-49"	>50"	2	8
TOTALS	52						84

AVERAGE RATING = (SUM OF WEIGHTED SCORES)/(SUM OF FACTOR WEIGHTS) = 1.62

DESCRIPTIVE RATING = MODERATE

Low	0.0-0.6
Low/Moderate	0.7-1.2
Moderate	1.3-1.8
Moderate/High	1.9-2.4
High	2.5-3.0

Table 4. Watershed sensitivity rating for Willow Creek

WATERSHED SENSITIVITY FACTOR	FACTOR WEIGHT (1-10)	Low 0	• • • • • 1	• • • • • 2	High 3	SCORE	WEIGHTED SCORE
Percent of watershed having HIGH to VERY HIGH EHR	5	$\boxed{< 10\%}$	10%-20%	21%-40%	> 40%	0	0
Percent of stream miles in stream types B and C	5	< 10%	10%-25%	26%-50%	$\boxed{> 50\%}$	3	15
Percent of all B and C type streams in DEGRADED condition	9	< 5%	5%-15%	16%-25%	$\boxed{> 25\%}$	3	27
Percent of watershed classified as RIPARIAN	2	< 1%	$\boxed{1.1\%-3.0\%}$	3.1%-5.0%	> 5.0%	1	2
Percent of watershed classified as INNER GORGE ZONE	6	$\boxed{0\%}$	0.1%-2.0%	2.1%-4.0%	> 4.0%	0	0
Percent of watershed over 60 % slope	5	$\boxed{< 5\%}$	6%-10%	11%-20%	> 20%	0	0
Percent of area occupied by landslides	10	0%	$\boxed{0.1\%-3.0\%}$	3.1%-9.0%	> 9.0%	1	10
Mean elevation	5	> 6000'	5500-6000'	$\boxed{5000-5500'}$	<5000'	2	10
Mean annual precipitation	4	> 20"	$\boxed{21"-34"}$	35"-49"	>50"	1	4
TOTALS	52						1.31

AVERAGE RATING = (SUM OF WEIGHTED SCORES)/(SUM OF FACTOR WEIGHTS) = 1.31

DESCRIPTIVE RATING = MODERATE

Low	0.0-0.6
Low/Moderate	0.7-1.2
Moderate	1.3-1.8
Moderate/High	1.9-2.4
High	2.5-3.0

Table 5. Watershed sensitivity rating for Nelson Creek.

WATERSHED SENSITIVITY FACTOR	FACTOR WEIGHT (1-10)	Low 0	• • • • • 1	• • • • • 2	High 3	SCORE	WEIGHTED SCORE
Percent of watershed having HIGH to VERY HIGH EHR	5	< 10%	10%-20%	21%-40%	> 40%	2	10
Percent of stream miles in stream types B and C	5	< 10%	10%-25%	26%-50%	> 50%	2	10
Percent of all B and C type streams in DEGRADED condition	9	< 5%	5%-15%	16%-25%	> 25%	1	9
Percent of watershed classified as RIPARIAN	2	< 1%	1.1%-3.0%	3.1%-5.0%	> 5.0%	3	6
Percent of watershed classified as INNER GORGE ZONE	6	0%	0.1%-2.0%	2.1%-4.0%	> 4.0%	2	12
Percent of watershed over 60 % slope	5	< 5%	6%-10%	11%-20%	> 20%	1	5
Percent of area occupied by landslides	10	0%	0.1%-3.0%	3.1%-9.0%	> 9.0%	3	30
Mean elevation	5	> 6000'	5500-6000'	5000-5500'	<5000'	2	10
Mean annual precipitation	4	> 20"	21"-34"	35"-49"	>50"	3	12
TOTALS	52						104

AVERAGE RATING = (SUM OF WEIGHTED SCORES)/(SUM OF FACTOR WEIGHTS) = 2.00

DESCRIPTIVE RATING = MODERATE/HIGH

Low	0.0-0.6
Low/Moderate	0.7-1.2
Moderate	1.3-1.8
Moderate/High	1.9-2.4
High	2.5-3.0

Table 6. Watershed sensitivity rating for Poplar Creek

WATERSHED SENSITIVITY FACTOR	FACTOR WEIGHT (1-10)	Low 0	• • • • • 1	• • • • • 2	High 3	SCORE	WEIGHTED SCORE
Percent of watershed having HIGH to VERY HIGH EHR	5	< 10%	10%-20%	21%-40%	> 40%	2	10
Percent of stream miles in stream types B and C	5	< 10%	10%-25%	26%-50%	> 50%	2	10
Percent of all B and C type streams in DEGRADED condition	9	< 5%	5%-15%	16%-25%	> 25%	3	27
Percent of watershed classified as RIPARIAN	2	< 1%	1.1%-3.0%	3.1%-5.0%	> 5.0%	1	2
Percent of watershed classified as INNER GORGE ZONE	6	0%	0.1%-2.0%	2.1%-4.0%	> 4.0%	1	6
Percent of watershed over 60 % slope	5	< 5%	6%-10%	11%-20%	> 20%	0	0
Percent of area occupied by landslides	10	0%	0.1%-3.0%	3.1%-9.0%	> 9.0%	1	10
Mean elevation	5	> 6000'	5500-6000'	5000-5500'	<5000'	2	10
Mean annual precipitation	4	> 20"	21"-34"	35"-49"	>50"	2	8
TOTALS	52						83

AVERAGE RATING = (SUM OF WEIGHTED SCORES)/(SUM OF FACTOR WEIGHTS) = 1.6

DESCRIPTIVE RATING = MODERATE

Low	0.0-0.6
Low/Moderate	0.7-1.2
Moderate	1.3-1.8
Moderate/High	1.9-2.4
High	2.5-3.0

Table 7. Watershed sensitivity rating for Jamison Creek

WATERSHED SENSITIVITY FACTOR	FACTOR WEIGHT (1-10)	Low 0	• • • • • 1	• • • • • 2	High 3	SCORE	WEIGHTED SCORE
Percent of watershed having HIGH to VERY HIGH EHR	5	< 10%	10%-20%	$\boxed{21\%\text{-}40\%}$	> 40%	2	10
Percent of stream miles in stream types B and C	5	< 10%	10%-25%	26%-50%	$\boxed{> 50\%}$	3	15
Percent of all B and C type streams in DEGRADED condition	9	< 5%	5%-15%	16%-25%	$\boxed{> 25\%}$	3	27
Percent of watershed classified as RIPARIAN	2	< 1%	1.1%-3.0%	3.1%-5.0%	$\boxed{> 5.0\%}$	3	6
Percent of watershed classified as INNER GORGE ZONE	6	0%	$\boxed{0.1\%\text{-}2.0\%}$	2.1%-4.0%	> 4.0%	1	6
Percent of watershed over 60 % slope	5	$\boxed{< 5\%}$	6%-10%	11%-20%	> 20%	0	0
Percent of area occupied by landslides	10	0%	$\boxed{0.1\%\text{-}3.0\%}$	3.1%-9.0%	> 9.0%	1	10
Mean elevation	5	> 6000'	5500-6000'	$\boxed{5000\text{-}5500'}$	<5000'	2	10
Mean annual precipitation	4	> 20"	21"-34"	$\boxed{35''\text{-}49''}$	>50"	2	8
TOTALS	52						92

AVERAGE RATING = (SUM OF WEIGHTED SCORES)/(SUM OF FACTOR WEIGHTS) = 1.77

DESCRIPTIVE RATING = MODERATE

Low	0.0-0.6
Low/Moderate	0.7-1.2
Moderate	1.3-1.8
Moderate/High	1.9-2.4
High	2.5-3.0

Table 8. Watershed sensitivity rating for Graeagle Creek.

WATERSHED SENSITIVITY FACTOR	FACTOR WEIGHT (1-10)	Low 0	• • • • • 1	• • • • • 2	High 3	SCORE	WEIGHTED SCORE
Percent of watershed having HIGH to VERY HIGH EHR	5	< 10%	10%-20%	21%-40%	> 40%	3	15
Percent of stream miles in stream types B and C	5	< 10%	10%-25%	26%-50%	> 50%	3	15
Percent of all B and C type streams in DEGRADED condition	9	< 5%	5%-15%	16%-25%	> 25%	3	27
Percent of watershed classified as RIPARIAN	2	< 1%	1.1%-3.0%	3.1%-5.0%	> 5.0%	3	6
Percent of watershed classified as INNER GORGE ZONE	6	0%	0.1%-2.0%	2.1%-4.0%	> 4.0%	0	0
Percent of watershed over 60 % slope	5	< 5%	6%-10%	11%-20%	> 20%	0	0
Percent of area occupied by landslides	10	0%	0.1%-3.0%	3.1%-9.0%	> 9.0%	0	0
Mean elevation	5	> 6000'	5500-6000'	5000-5500'	<5000'	2	10
Mean annual precipitation	4	> 20"	21"-34"	35"-49"	>50"	2	8
TOTALS	52						75

AVERAGE RATING = (SUM OF WEIGHTED SCORES)/(SUM OF FACTOR WEIGHTS) = 1.44

DESCRIPTIVE RATING = MODERATE

Low	0.0-0.6
Low/Moderate	0.7-1.2
Moderate	1.3-1.8
Moderate/High	1.9-2.4
High	2.5-3.0

Table 9. Watershed sensitivity rating for Sulphur Creek

WATERSHED SENSITIVITY FACTOR	FACTOR WEIGHT (1-10)	Low 0	• • • • • 1	• • • • • 2	High 3	SCORE	WEIGHTED SCORE
Percent of watershed having HIGH to VERY HIGH EHR	5	< 10%	10%-20%	21%-40%	> 40%	1	5
Percent of stream miles in stream types B and C	5	< 10%	10%-25%	26%-50%	> 50%	2	10
Percent of all B and C type streams in DEGRADED condition	9	< 5%	5%-15%	16%-25%	> 25%	3	27
Percent of watershed classified as RIPARIAN	2	< 1%	1.1%-3.0%	3.1%-5.0%	> 5.0%	2	4
Percent of watershed classified as INNER GORGE ZONE	6	0%	0.1%-2.0%	2.1%-4.0%	> 4.0%	1	6
Percent of watershed over 60 % slope	5	< 5%	6%-10%	11%-20%	> 20%	0	0
Percent of area occupied by landslides	10	0%	0.1%-3.0%	3.1%-9.0%	> 9.0%	1	10
Mean elevation	5	> 6000'	5500-6000'	5000-5500'	<5000'	1	5
Mean annual precipitation	4	> 20"	21"-34"	35"-49"	>50"	1	4
TOTALS	52						71

AVERAGE RATING = (SUM OF WEIGHTED SCORES)/(SUM OF FACTOR WEIGHTS) = 1.36

DESCRIPTIVE RATING = MODERATE

Low	0.0-0.6
Low/Moderate	0.7-1.2
Moderate	1.3-1.8
Moderate/High	1.9-2.4
High	2.5-3.0

become degraded, these alluvial deposits represent an in-channel source of sediments which can rapidly degrade water quality through stream side-cutting processes.

The "percentage of the watershed classified as inner gorge zone" (i.e., adjacent to the stream channel and over 60 percent slope) factor was rated slightly above moderate (6). Inner gorge zones are sensitive to land disturbance activities. Cloud seeding will not introduce any site disturbance in this zone. Inner gorge zones in the project area frequently contain landslide features which could be influenced by the project through increased peak flows or increased soil moisture.

The "percentage of the watershed over 60 percent slope" factor received a moderate (5) rating. Most of the areas containing slopes greater than 60 percent are also included in the high to very high erosion hazard rating, inner gorge zone or landslide factors. This factor was given a moderate rating because it influences storm water travel times and slope stability.

The "percentage of the watershed classified in a landslide condition" (both active and inactive) received the maximum weight (10) because it is the prime indicator of watershed sensitivity from a cloud seeding program. Landslides can directly impact water quality and fisheries habitat. A single active landslide can contribute more sediment than all other sources in a watershed.

The "mean elevation" factor received a moderate rating (5). Most sensitivity analyses score higher elevations as more sensitive to disturbance due to the shorter growing season and subsequent longer recovery period following disturbance. However, lower elevations are more likely to be adversely impacted by a major rain on snow event (a prime concern to the appellants). For this reason, lower elevations received a higher score in the sensitivity analyses.

"Mean annual precipitation" received a moderate rating (4), as precipitation amount can influence vegetation, landsliding and channel stability. Like the previous factor, most sensitivity analyses score areas with less annual precipitation higher due to the longer recovery period following disturbance. Negligible site disturbances will be produced by this project. Higher precipitation areas received a higher score in this CWE analysis due to the greater potential for a rain on snow event. Increased precipitation is less likely to induce channel degradation, or landsliding in areas of low average annual precipitation.

<u>Water Tolerance to Land Use</u>

When a watershed's tolerance to the accumulation of land uses reaches a threshold, significant downstream degradation is expected to occur. This "threshold of concern" (TOC) is expressed in equivalent roaded area (ERA) percentages. The ERA methodology assumes that watersheds can tolerate a given level of land disturbance without a substantial impact to downstream beneficial uses and that the approximate point where adverse effects begin to occur can be identified. TOC represents the upper limits of a watersheds tolerance to land use before degradation of downstream beneficial uses begin to occur. Since a watershed's actual threshold cannot be determined, a level of concern, called TOC, is determined.

TOC's were developed for each watershed by the cloud seeding interdisciplinary (I.D.) team and are based on current professional consensus (Table 10). These TOC values were significantly reduced from those historically employed on the Plumas National Forest and in the U.S.F.S. Soil and Water Conservation Handbook. The larger the watershed area, the more dilute the effects of the impacts that occur in it. Those TOC values normally used by the Plumas National Forest were estimated for much smaller watershed areas. To account for the larger watershed areas and the dilution affect, lowered TOC values were developed.

Table 10. Threshold of Concern "TOC" Values

Watershed	TOC Value
Squirrel Creek	10
Greenhorn Creek	10
Estray Creek	10
Willow Creek	9
Nelson Creek	8
Poplar Creek	10
Jamison Creek	9
Graeagle Creek	10
Sulphur Creek	9
Long Valley Creek	12
Little Long Valley Creek	12
Consignee Creek	12
Jackson Creek	12

Land Use Activities

Different types and intensities of land disturbance activities obviously result in highly variable watershed impact. Each forest has developed local, area specific disturbance coefficients representative of the range of values that each type of activity can be expected to produce. These coefficients are related to the amount of disturbance created by one acre of road.

The cloud seeding I.D. team analyzed CWEs using a conservative approach. Areas impacted and coefficients used to identify relative impacts are slightly inflated to account for unaccounted, but expected, impacts. The criteria and assumptions used in this CWE analysis are identified below.

"Roads" include all highways, secondary roads, jeep trails, railroads, power lines, log landings and cow trails visible on 1 to 30,000 scale aerial false color infra-red photographs. Each "road" was assigned a prism width of 35 feet and an ERA coefficient value of 1.0. This width tends to significantly overestimate the acreage of jeep trails, skid trails, cow trails and secondary roads on slopes less than 30 percent and under estimates highways, railroads, log landings, and roads on slopes steeper than 45 percent. Assuming a coefficient value of 1.0 over the entire road prism also tends to overestimate the compaction generally found on fill slopes within the road prism but helps to account for the oversteepened, usually bare road prism cut slopes.

Subdivision developments were outlined on the infra-red photographs. Miles of roads within the outlined subdivision were calculated and doubled to compensate for the presence of impervious structures and compaction associated with human occupation (i.e. roofs, sidewalks, patios, etc.). Subdivision values are included as roads in the ERA calculations. Subdivisions were identified in several watersheds including Graeagle Creek, Jamison Creek, Willow Creek and Sulphur Creek.

All timber harvest activities on public and private lands since 1981 were compiled and included in this CWE analysis. USFS records were the source of timber harvest information on public lands. California Department of Forestry and Fire Protection Timber Harvest Plan files were the source for timber harvest activities on private lands. Ten years was selected as the temporal limit based on observed recovery rates of logged or burned areas on the Plumas National Forest. Transect data indicate that within 10 years of these types of land disturbances, vegetative recovery is at 95 to 100 percent of pre-disturbance levels (Ken Robie, USFS Hydrologist, pers. comm.). However, as a conservative approach, timber harvest recovery curves used for the last decade of timber harvest are those developed for the Last Chance Creek watershed (Cawley 1991). The Last Chance Creek watershed receives 18 to 30 inches of precipitation annually and is classified as semi-arid. Lower annual precipitation in the Last Chance Creek watershed produces longer recovery periods (25 to 40 years) following disturbance than those found in the majority of the project area. Vegetative recovery within the project area should be more rapid than is projected by these conservative recovery curves.

Proposed timber harvest on public lands through 1993 are included in the current ERA value. Projected ERA values for public lands timber harvest included planned timber harvest during 1994, 1995 and 1996. Future ERA values for public lands timber harvest were calculated using a typical 10 million board feet sale which involves three miles of new road construction, tractor logging of 200 acres of clearcut and 500 acres of intermediate harvest. Current private timber harvest information includes only those timber harvest plans on file with the CDF. Private timber management companies were contacted directly to develop estimates of future timber harvest activities on private lands within the project area. These companies were unable to project their harvest plans which respond rapidly to current market prices. To project private lands timber harvest over the next five years (the life of the prototype cloud seeding project), the watershed with the highest private lands timber harvest ERA per acre of private timber land over the last ten years was used as a model. This rate of harvest was applied to each watershed over the next five years to develop projected ERA values.

Timber harvest ERA coefficients employed include 0.35 for tractor logged clearcuts and 0.20 for tractor logged intermediate cuts and salvage sales. These values represent the maximum in the range of coefficient values developed for timber harvest on the Plumas National Forest. These coefficient values take into account all timber management activities including site preparation.

No grazing coefficients have been developed on the Plumas National Forest. The Lassen National Forest uses coefficient values of 0.01 to simulate moderate grazing effects and 0.02 to represent more intensive grazing. These coefficient values were developed relative to other land use impacts rather than from transect data. The interdisciplinary team for the cloud seeding CWE study modified these values to 0.05 for moderate grazing and 0.1 for more intensive grazing. No recovery coefficients were employed in areas currently being grazed. Acres grazed and intensities were identified from range allotment data files, air photos, site visits, and discussion with USFS resources personnel.

Large wildfires occur infrequently within the project area, but can remove vegetation from large areas. Hydrophobic soils, a condition which reduces the rate of precipitation infiltration into soils is common during the first year following wildfires. Wildfire locations were identified from the USFS fire atlas. Subsequent salvage logging impacts were added to burn coefficients. Recovery coefficients were used to simulate vegetative recovery following wildfire.

Mining impacts including hydraulic mining scars, mine tailings, and gravel removal were identified from air photos and through discussion with district resources personnel. Mining impacts were assigned a coefficient value of 1.0, and no recovery coefficients were used. No change in the ERA values for mining or grazing are projected due to their ongoing nature. Natural disturbances such as wildfire are not projected.

Current ERA calculations are presented in Appendix A (Tables 1 through 9). Projected ERA calculations through the 1996-1997 water year are presented in Appendix A (Tables 10 through 22). A composite summary of TOC, current and projected ERA and current and projected percent of TOC are presented in Table 11.

<u>CWE Susceptibility Evaluation</u>

One watershed within the project area is currently over TOC (Figure 11). Jackson Creek watershed was largely denuded by wildfire during 1989. Salvage logging further impacted this watershed during 1990 and 1991. Subsequent vegetative recovery following these impacts has occurred, but the current ERA value remains approximately 74 percent greater than the TOC. Projected vegetative recovery data indicate that, barring unplanned disturbance, the Jackson Creek watershed will remain over TOC until approximately 1994. Beneficial uses have been impacted in this watershed. Increased erosion, sedimentation, peak flow, and water temperature have degraded the coldwater fishery within Jackson Creek. No degradation of water

Table 11. Summary of TOC and Current and Projected ERA Values

Watershed	TOC	Current ERA	Current % of TOC	Projected ERA	Projected % of TOC
Squirrel Creek	10	5.1	51.0	9.5	95.0
Greenhorn Creek	10	6.9	69.0	9.1	91.0
Estray Creek	10	5.7	57.0	7.3	73.0
Willow Creek	9	6.9	76.6	7.3	81.1
Nelson Creek	8	2.0	25.0	2.8	35.0
Poplar Creek	10	3.9	39.0	6.8	68.0
Jamison Creek	9	3.6	39.9	3.3	36.7
Graeagle Creek	10	3.5	35.0	3.5	35.0
Sulphur Creek	9	7.6	84.4	8.9	98.9
Long Valley Creek	12	10.9	90.8	12.6	104.9
Little Long Valley Creek	12	9.5	79.2	9.8	81.6
Consignee Creek	12	11.2	93.3	11.3	94.2
Jackson Creek	12	20.9	174.9	11.0	91.6

quality or coldwater fish habitat quality within the Middle Fork Feather River downstream from Jackson Creek have been observed.

Flood flows due to a wet year, an intense summer thunderstorm, or a landslide could retard the recovery of this watershed or damage it permanently.

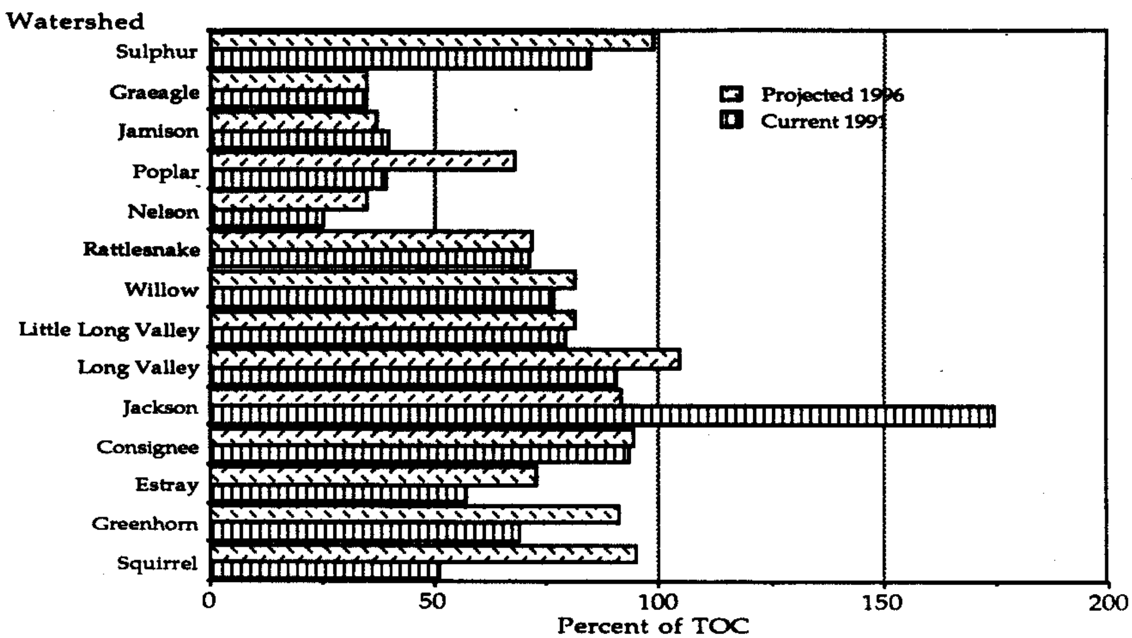
Consignee Creek, Long Valley Creek, and Little Long Valley Creek are all approaching TOC. No adverse effects to any beneficial use are apparent. Long Valley Creek is considered to possess an excellent coldwater fishery (Leslie Mink, USFS Fishery Biologist, pers comm.). No fisheries data have been collected on Little Long Valley Creek or Consignee Creek. Consignee Creek may not contain a fishery due to stream barriers at the mouth (Tom Ratcliff, USFS Wildlife Biologist, pers. comm.).

Projected ERA values (Figure 11) indicate that by 1996-1997, the watersheds of Squirrel Creek, Greenhorn Creek, Sulphur Creek and Long Valley Creek could be at or over TOC. It is apparent from this analysis, that most of the project area has been heavily impacted and, even using a conservative evaluation approach, can be expected to develop significant problems in the future unless the current trend is reversed. These problems are not expected to be measurably increased, if at all, by the cloud seeding project. This projection is based on the following examination of the CWE mechanisms associated with snowpack augmentation.

<u>CWE's Mechanisms Associated With Snow Augmentation That Cause Cumulative Watershed Effects (CWE)</u>

The cloud seeding I.D. team reviewed the project design, suspension criteria, scientific analysis of other cloud seeding programs and concluded that: 1) adverse watershed effects from the proposed snow augmentation project are expected to be insignificant and undetectable using normal operating procedures; 2) adverse watershed effects should potentially occur only during major rain on snow events;

Figure 11. Current and projected ERA values expressed as percent TOC.



and 3) increases in landsliding and peak flows are the most probable CWE impacts which could be produced by the project during a major rain on snow event.

The following discussion examines the proposed prototype snow augmentation project's influence on various types of mass movement during a major rain on snow event and is largely based on the results of scientific monitoring studies conducted by the Bureau of Reclamation in the San Juan Mountains of Colorado (Caine 1976).

Obviously, environmental conditions differ substantially between the San Juan area and the northern Sierra Nevada. Some dangers always exist in applying the results of a study to another area with different environmental conditions. Unfortunately, no comparable studies have yet been conducted in the Sierra Nevada Mountains. The results from the San Juan study represent the best available scientific information on the effects of snowpack augmentation on geomorphic processes. The very cold temperatures and sparse vegetation of the alpine San Juan Mountains would tend to be more sensitive to changes in precipitation than might occur in the forested Sierra Nevada's (Kattleman 1985).

Snow avalanches do occur within the project area and are capable of moving rock and soil downslope. Snow avalanches in the Sierra Nevada's are typically wet in nature and are usually triggered by rainfall (Kattleman 1985). Rainfall intensity, irrespective of snowpack depth, has been observed to produce snow avalanches (Kattleman 1985). The project's seeding criteria are specifically designed to eliminate increases in rainfall.

Soil creep is the slow downslope movement of surface material that results from frost heaving and subsequent vertical settling of thawed particles. Additional water can accelerate the creep process. However, snow cover insulates the soil and prevents frost-induced soil creep. Monitoring of snow augmentation in the San Juan Mountains indicates that soil creep was probably not affected by changes in snowpack (Caine 1976).

Solifluction and slumping are the downslope movements of soil as a water-saturated mass. They are common in alpine areas where an impervious layer prevents ground water percolation but can also occur under saturated soil conditions wherever the downslope support for a soil unit has been removed. Road cuts, mining and timber harvest which are abundant in the project area can remove downslope support and result in slope movement. Additional snowmelt and resulting higher soil saturation levels produced through snow augmentation could cause a mass movement to occur where the susceptibility for such an occurrence is high.

Mudflows, the channelized flow of water-saturated soil, differ from solifluction due to their greater speed and confinement to an existing channel. Field measurements in the San Juan Mountains indicate this process is normally initiated by intense rainfall. A major rain on snow event could trigger mudflows in the snow transition zone, especially in some of the project area soils derived from pyroclastic volcanic material. The proposed snow augmentation project could increase the risk of initiating mudflows in the transition zone during a major rain on snow event if the snow augmentation resulted in the presence of snow where none would have been present without cloud seeding. Although it is theoretically possible to produce snow cover through cloud seeding where none would have occurred without cloud seeding, it is, at best, a remote possibility. Such an event offers snow augmentation researchers the best opportunity to quantify the contribution of their cloud seeding effort. However, cloud seeding researchers in a ten year study conducted in the American River Basin were unable to produce such a situation (Dave Reynolds, U.S.B.R., pers. comm.). In deeper snowpack above the transition zone, the depth of snow has no significant effect on the melt rate of snow. Snow melt rates are primarily controlled by rainfall intensity, air temperature, tree cover and wind.

Rockfall, the process through which individual pieces of a cliff become detached and fall vertically, is principally controlled by freeze-thaw action in the Sierra Nevada's and often occurs following road construction and mining. Increased snowmelt associated with cloud seeding could incrementally increase the moisture available for this process.

Landslides and debris avalanches are catastrophic events involving movement of massive quantities of material. Both processes are infrequent events which can produce more sediment in a few seconds than other more continuous geomorphic process can produce over a century. Increased pore pressure resulting from intense or prolonged rainfall appears to be the main cause of slope failure (Sidle, et al. 1985). Water can trigger landslides in a variety of ways including seepage pressure, reduction of capillary tension, buoyancy, liquefaction, addition of weight, decrease in soil aggregation, and undercutting (Selby 1982). Whenever surface infiltration exceeds the subsurface flow rate (which can occur during periods of prolonged intense rainfall or snowmelt) pore pressure increases. Subsurface flow rate controls the accumulation of soil water during a major rain on snow event. Prolonged periods where infiltration exceeds ground water outflow can result in increased height of the saturated zone and can lead to slope instability.

Modeling of both a 15- and 50-year rain on snow event within the project area indicates that cloud seeding has virtually no impact on peak flows (Appendix B). The small incremental increase in snowpack created through cloud seeding absorbs a small portion of the precipitation early in the rain on snow event. This ability of snow to absorb a small amount of rainfall affects landslides by reducing total flows during rainfall events. The slight moderating effect on total flows serves to reduce undercutting of landslides adjacent to stream channels.

The EIS states that cloud seeding will result in an extended period of snowmelt (estimated at 3 to 7 day maximum). This additional snowmelt, derived from cloud seeding, produces slightly increased ground water levels. These higher ground water levels are projected to dissipate within 4 to 9 days. This projection is based on field studies conducted near Soda Springs in the American River Basin (McDonald 1986, 1987). If a major precipitation event should occur during this 4 to 9 day period that ground water levels are elevated due to cloud seeding, then the increased risk of landsliding could occur as a result of the project.

Researchers have speculated that cloud seeding has the potential to affect mass movement during a major rain on snow event through increased risk of slope movement in disturbed areas, in areas denuded of vegetation (wildfire and clearcuts), and by increasing ground water levels due to the extended snowmelt period. Reduced total flows during rain on snow events, and reduction of the rate of surface infiltration, as well as stimulation of vegetative growth from the proposed project could incrementally reduce the potential for mass movement. Long term scientific monitoring studies conducted in concert with other cloud seeding programs have been unable to detect any incremental effects (either positive or negative) on any mass movement processes. The effects of this cloud seeding program on mass movement are not expected to be any different, especially with the established seeding and suspension criteria.

There is currently no method to quantify how much additional instability could occur as a result of increased snowpack. Since mass movements occur more frequently after heavy or long duration rainfall or runoff events, the effect of small incremental increases in precipitation on slope instability will probably not be measurable during the periods when the project will be operational.

The hydrologic effects of a major rain on snow event in the project area were modeled for a ten square mile area of the upper Greenhorn Creek watershed (Appendix B). The upper Greenhorn Creek watershed was selected to represent a "worst case" situation because 1) it is entirely within the project area; 2) it contains a relatively high percent area in the rain-snow transition zone; 3) CWE projections indicate that this watershed will approach TOC by 1996; and 4) it has relatively high annual precipitation. The upper Greenhorn Creek watershed contains approximately 6,736 acres.

The following discussion summarizes the results of this hydrologic model. During a simulated 15-year rain on snow event, the proposed project (assuming a 10 percent increase in snow pack) has little impact on peak flows. The small incremental increase in snow absorbs a small portion of the rainfall early in the storm and produces a slight (less than one percent) decrease in peak flow. The same storm event was repeated with less initial snowpack in an effort to have all the low elevation snow removed. However, the 10 percent increase in snow produced through cloud seeding again absorbed a slight amount of the precipitation early in the storm, with the peak flow virtually identical. A 50-year rain on snow event was simulated with both the observed and simulated shallow snowpack, both having 10 percent additional snow water equivalent added. Results of these two scenarios indicate no change in peak flow.

These model results confirm what was stated in the EIS. That is, an additional 10 percent increase in snowpack water content will have no impact on flooding or watershed degradation during a rain on snow event.

Mitigation Measures

Suspension criteria employed were designed to mitigate adverse impacts and protect beneficial uses. No additional mitigation measures are recommended. However, the Department of Water Resources and the U.S. Forest Service are both active members of the East Branch North Fork Feather River Coordinated Resources Management (CRM) group and the newly forming Jamison Creek CRM group. The CRM process is designed to facilitate solving cumulative watershed effects problems in multiple ownership and use watersheds. Both agencies will be active participants in any CRM activities conducted within and outside the project area.

Monitoring and Evaluation

During January 1991, the Department of Water Resources proposed and implemented an environmental monitoring program which was designed to document changes in physical water quality parameters, selected nutrient concentrations, sediment production, benthic macroinvertebrate populations, fish populations, and surface erosion rates. Sampling sites selected included the Middle Fork Feather River above and below the project area, Nelson Creek, Long Valley Creek, Jamison Creek and Willow Creek. The approved monitoring plan is presented in Appendix C. The Department has a program designed to monitor changes in surface erosion and mass movement rates, scheduled to begin data collection in the Middle Fork Feather River during 1992. This program is not associated with the cloud seeding program, but information derived from this program will be very useful in tracking changes in watershed conditions. The cloud seeding program could be modified based on the results of these studies.

ISSUE 3. The effects of the project on sensitive, threatened and endangered wildlife species need to be better addressed. (Appeal Item 6c).

DIRECTION

Supplement the EIS with a biological evaluation for sensitive, threatened and endangered wildlife species in the project area as per FSM 2672.4. This evaluation will determine if snowpack augmentation will adversely effect the sensitive, threatened and endangered wildlife species or their habitat.

DISCUSSION

This biological assessment examines the potential for adverse effects on endangered, threatened, proposed and sensitive wildlife species and their habitats resulting from the five year prototype cloud seeding program. The "listed" species of known or suspected occurrence within the project area are presented in Table 12, which was developed in consultation with Plumas National Forest wildlife personnel.

Table 12. "Listed" wildlife species of known or suspected occurrence within the cloud seeding project area (USFWS = F, State = S, USFS =FS).

Common Name	Scientific Name	Status
bald eagle	Haliaeetus leucocephalus	S+F-Endangered
California spotted owl	Strix occidentalis	FS-Sensitive
American peregrine falcon	Falco peregrinus anatum	S+F-Endangered
wolverine	Gulo gulo	S-Threatened; F-Candidate
Sierra Nevada red fox	Vulpes vulpes necator	S-Threatened; F-Candidate
willow flycatcher	Empidonax traillii	FS-Sensitive
Northern goshawk	Accipiter gentilis	FS-Sensitive
golden eagle	Aquila chrysaetos	F-Protected
pine martin	Martes americana	FS-Sensitive

All of the species identified in Table 12 may occur within the project area except the Sierra Nevada red fox. The following discussion briefly summarizes the known distribution and occurrence of "listed" species within the project area. Where appropriate, discussion of potential habitat is included.

No nesting bald eagles are known to occur within the project area. However, two active (i.e., recent reproductive behavior) nests are located at Lake Davis within 5 miles of the project boundary. Three known or suspected winter roost sites occur within the project boundary. All three are located on either the north or east boundaries of the project area. The Middle Fork Feather River, which bisects the project area, is heavily used by wintering bald eagles. Mid-winter bald eagle count information indicates that the Middle Fork Feather River is used for loafing, foraging and as a travel corridor.

Approximately 15 pairs of spotted owls are known to nest within the project area. Two propane dispensing sites are located within active spotted owl territories (propane dispenser No. 2 and No. 5). One precipitation gauging station is also located within an active spotted owl territory (precipitation gauge No. 10). This spotted owl territory is closed to entry from March 1 through August 31. If alternative sites for propane dispensers and precipitation gauges cannot be selected, then required maintenance and spring removal of these facilities may be affected. Both spotted owls and goshawks winter within the project area and may move downslope during periods of inclement weather.

No known peregrine falcon nest sites occur within the project area. Currently unoccupied, marginally suitable cliff nesting sites occur throughout the project area. Sporadic historical sightings of migrating or wintering peregrine falcons have occurred throughout the project area.

At least three wolverine sightings have occurred in the Lakes Basin Area, which is located adjacent to the most southeast propane dispenser site. The most recent sighting was in 1988. Wolverines have large home ranges and are reported to use timbered ridgetops as travel corridors (Ingram 1973). Wolverines present in the Lakes Basin Area could be expected to utilize the high elevation ridge where the propane dispensers are located.

No historical sightings of Sierra Nevada red fox have been recorded within the project area. Suitable habitat for this species may exist at McRae Meadows and along the Middle Fork Feather River between Portola and Beckwourth.

Willow flycatchers have been observed in the project area, between Portola and Beckwourth. Suitable habitat may exist at McRae Meadows, along the Feather River near Sloat, near Gray Eagle, and possibly along the tributaries to Lake Davis. The Sloat habitat is probably marginal. The tributaries to Lake Davis are approximately 3 to 4 miles north of the project boundary.

At least 12 active Goshawk nest territories occur within the project area. The majority of these territories are in close proximity to or overlap spotted owl territories. Propane dispenser and precipitation gauging station locations are not located in any known goshawk territories.

Three golden eagle nest territories (two active and one abandoned) occur within the project area. Two of these sites are located along the Middle Fork Feather River between Eureka Creek and Smith Creek. Both nests are located on north-facing cliffs adjacent to the river. The third golden eagle nest site is located at the northeast edge of the project area near Beckwourth.

Marten sightings have occurred in the Gibraltar Peak Area, Lakes Basin Area, Haskell Peak Area and in the Sulphur Creek drainage within the project area. Martin sightings are fairly common in the area proposed for propane dispenser sites.

Due to the lack of field reconnaissance, we must assume that all the "listed" species in Table 12 occur within the project area. Suitable potential (although unsurveyed) habitat exists within the project area to support Sierra Nevada red fox, though this species is not known to occur in the area.

Environmental Effects of Cloud Seeding

To evaluate the project influence on listed species, it is necessary to identify the project's environmental effects, including the effects of required maintenance and monitoring activities. The EIS was used to identify the projects potential environmental effects. Those potential environmental effects of the project identified from information in the EIS include increased risk of avalanche, increased snow depth, increased precipitation amount and intensity, increased soil moisture, increased risk of collision (helicopter and propane dispensing towers), increased risk of human disturbance, delayed snow melt, impact to species management activities and cumulative effect.

Several other potential environmental effects were examined and dismissed based on information provided in the EIS. These effects include propane leaks, fire and out of target area effects. Liquid propane vaporizes readily. Due to the low probability of leaks and the ridge top locations (which serve to disperse the propane gas) it is unlikely that even if a leak should occur that a listed species in the immediate area would be injured. Likewise the potential for a damaging fire is quite low considering the season of operation and natural clearing near the rock ridgeline where dispensers will be installed. Out of area effects, if any, are anticipated to be below detection limits since ice crystals formed from propane release are expected to grow rapidly and fall as snow primarily within the target area.

Those environmental effects identified in the EIS which could potentially influence listed species were used as evaluation criteria. The effect of each of these evaluation criteria on each of the listed species' food, water, cover, reproduction and special habitat needs was assessed.

Avalanche - The EIS states that project operations may have a contributory effect on snowpack conditions which lead to avalanche conditions. U. S. Forest Service records indicate that none of the "listed" avian species are known to nest in areas prone to avalanche. Wolverine, marten and Sierra Nevada red fox all could and undoubtedly do occur in avalanche prone areas. Accidental death of these forbearers due to avalanche is possible but judged to be highly unlikely. The Department of Water Resources will suspend seeding activities when critical avalanche hazards are judged to exist. Suspension criteria are identified in the EIS.

Increased Snowpack - The goal of this cloud seeding program is to increase water yields through increased snowpack. Snowpack depths above 5,900 feet are expected to be greater than they would be without the project by approximately 10 percent. During the winter, food sources for raptors and forbearers are reduced due to snow cover and mammalian hibernation. Due to the mobility of the listed species and the steepness of the terrain, the incremental increase in snow depth may result in a temporary short downslope movement by some of the listed species. This is the normal response of these species to increased snowpack. The cloud seeding program will primarily operate in years of normal or below normal precipitation. Snow depths produced should be well within the normal range of depths to which these species are adapted.

Bald eagles have been documented to migrate further south during colder winters (Steenhof 1978). A 10 percent increase in snowpack should not significantly alter species distribution or adversely impact any of the listed species.

Heavy snowfall can damage or destroy eagle tree nests. The only eagle tree nest in the project area is located north of Beckwourth. This golden eagle nest is located below the 5,500 foot snowline and in an area which normally receives 15 to 20 inches of precipitation annually. Most of the limited precipitation at this site is in the form of rain, thus snow damage seems unlikely. The project will not decrease the elevation at which snow falls nor will it effect daily temperature regimes.

Increased Precipitation Amounts and Intensity - The EIS indicates that cloud seeding activities will increase precipitation by an average of 0.08 inches above 4,500 feet during an eight hour storm event. Assuming a reasonably even distribution of precipitation, these levels of increased precipitation amount and intensity should pose no adverse effects to any "listed" species.

Increased Soil Moisture - The EIS projects that a full season of cloud seeding will produce an extra 2 inches of precipitation. Approximately 2/3 of this increase will leave the area as runoff while the remaining 1/3 will infiltrate into the soil column and be lost through evapotranspiration. The extra 0.6 to 0.7 inches of precipitation may slightly increase soil moisture. This slight increase will probably not be measurable. Although an increase in soil moisture could largely be beneficial to listed species (during years of normal or below normal rainfall when the project will be operating), the small amount of increase will probably not significantly benefit listed species. The EIS states that the project will temporarily increase ground water levels, and increase the period of stream and spring flow. These increases could dampen the effects of drought in below rainfall years. Increased streamflow would benefit willow flycatchers, spotted owls, goshawks, bald eagles, and Sierra Nevada red fox whose use of riparian habitats is disproportionately higher than it's occurrence.

Collision - Both the propane dispensing towers and the helicopter used to install and remove them are subject to collision by raptors. Nesting raptors, particularly eagles, goshawks, osprey and falcons, defend their nest territories from other large avian species. These raptors incorrectly identify helicopters as large avian threats and respond by attacking. The California Department of Forestry has adopted guidelines for helicopter operations around known peregrine nest sites. The fall installation is outside the critical nesting season of listed raptors. Helicopter crews will be advised of the guidelines for operating near raptor nests, but will avoid all known nest sites. The Department will check all flight paths, particularly near suitable cliff sites prior to spring removal of the propane dispensers. Helicopter flights will be coordinated to avoid areas of human settlement and any new raptor nest sites discovered.

Collisions between raptors and propane dispenser towers during inclement weather is possible, but unlikely. These towers are 13 feet in height and fairly narrow (8 to 10 inches maximum). Due to their placement on rocky ridge tops, it is likely that these towers would be attractive raptor perch sites. Lack of cover and turbulent conditions probably preclude their use during periods of cloud seeding operations. Raptors perched on the towers during cloud seeding operations would not be asphyxiated since the propane vaporizes instantly. The chemical reaction during vaporization produces extremely cold temperatures (-100 F), which should further discourage raptor use during cloud seeding operations. Each site will be inspected annually for signs of raptor-tower collision. Results of this survey will be provided to the Plumas National Forest.

Increased Human Disturbance - The project should induce minimal human disturbance into the area. Approximately one-half day will be required for fall installation of all sites. An equivalent amount of time will be required for spring removal of the propane dispensing system. Unplanned visits (between installation and removal) will occur only in the event of equipment failure. Access for equipment repair will be by snowmobile, snowcat, or helicopter. The adverse effects of intensive snowmobile use on wildlife is well documented (Baldwin 1968, Doan 1970, Newman and Merriam 1972). Snowmobile activity around bald eagle winter roost sites are a serious disturbance factor (Ingram 1965) and can adversely impact wolverines (Ingram 1973). All access between March 1 and August 31 will be coordinated with U. S. Forest Service wildlife personnel to avoid known raptor nest sites. Spotted owls, golden eagles, peregine falcons and bald eagles begin to nest on the Plumas National Forest around March 1. Entry will be very minor, limited only to emergency repairs, thus eliminating or greatly reducing effects to wildlife. Operations and maintenance personnel will be cautioned on the dangers to wildlife from snowmobile harassment.

Delayed Snowmelt - The EIS projects that the period of snowmelt will be extended an average of 1 to 3 days in the project area. Snowmelt may, however, be extended for a slightly longer period in sheltered micro-habitats. Steep north-facing slopes and areas of dense coniferous cover are examples of sheltered micro-habitats. They are also the micro-habitats selected by spotted owls and goshawks for nesting. Goshawks do not begin nesting activities until approximately May 1, but spotted owls become active around March 1. The EIS states that the cloud seeding program will operate only in years of normal and below normal precipitation. The period of snowmelt during years of average or less precipitation will be well within the time range to which listed species in the area are adapted. The short period of delayed snowmelt, even in sheltered micro-habitats, should not adversely effect any listed species.

Two golden eagle nests are located on north-facing cliffs above the Middle Fork Feather River. They are both located below the 5,000 foot snowline. Delayed snowmelt should not influence either nest site.

Impacts to Species Management Activities - Species management activities consist of active search for individuals of listed species, monitoring reproduction of known nest or den sites and determining habitat use of listed species.

None of the physical environmental effects of the proposed cloud seeding program should impair listed species management activities on the Plumas National Forest (Tom Ratcliff, Wildlife Biologist, Plumas National Forest, pers. comm.).

Cumulative Impacts - Cumulative impacts are by definition impacts which are singularly insignificant but may cumulatively adversely impact a species or its habitat. Discussion with Plumas National Forest wildlife personnel identified no cumulative impacts from this project or between this project and other activities currently underway in the project area. No cumulative impacts to "listed" wildlife species have been identified related to this cloud seeding program.

CONCLUSIONS

The potential impacts on listed species from the environmental effects of the cloud seeding program should be negligible. The cloud seeding program will not result in "take" of any listed species. No loss or adverse modification to habitats has been identified. Conversely, the cloud seeding program will not significantly benefit any listed species or their habitats.

Numerous public comments were received on the Draft EIS concerning the prototype project impacts on listed wildlife species. The public perception that the project will adversely impact listed species will not change unless populations of listed species are monitored and their status made public. The Department of Water Resources will assist the U. S. Forest Service in monitoring listed wildlife populations in the project area. Potential habitat will be identified and surveyed with special emphasis on the areas adjacent to propane dispensers and precipitation gauges where cloud seeding activities have the greatest potential influence on new or previously unknown individuals of "listed" species.

Biological Assessment Recommendations

1) Consult with U. S. Forest Service biologists concerning entry into spotted owl management areas prior to removing propane dispensers. If unacceptable effects due to entry are likely, the dispensers would be left during the critical period from March 1 through August 31. An alternative, if effects from entry are considered significant, is to eliminate placement of dispensers two and five.

2) Survey helicopter flight path annually for new or previously unknown nesting raptors (particularly eagles, osprey and falcons). Modify flight paths as necessary to avoid known raptor nest sites. Advise helicopter crews on how to avoid raptor/helicopter interactions.

3) Monitor annually for wildlife mortality around propane dispenser sites.

4) Advise the Department of Water Resources Operation and Maintenance personnel of the impact of snowmobile activities on wildlife and caution against intentional and unintentional harassment.

5) Contact U. S. Forest Service wildlife personnel before any entry into any of the propane dispensing sites or precipitation gauging stations within the period from March 1 through August 31. This contact will eliminate any unintentional entry into newly discovered "listed" species habitats.

6) Coordinate environmental monitoring activities (i.e. fisheries, erosion, sedimentation, water quality and rare plant studies) with U. S. Forest Service wildlife personnel to avoid entry into areas where wildlife closures are in effect.

7) Coordinate population monitoring of "listed" species with U. S. Forest Service wildlife personnel.

U. S. Forest Service Assessment Evaluation

Tom Ratcliff, East Zone Wildlife Biologist for the Plumas National Forest has reviewed the Biological Assessment, the Joint EIR/EIS for the Prototype Project to Augment Snowpack by Cloud Seeding Using Ground Based Dispensers in Plumas and Sierra Counties - November, 1990, and the Draft Supplement to the EIS. He concludes that in accordance with current Region 5 direction, this Biological Evaluation documents an assessment of the proposed Snowpack Augmentation project proposed by the California Department of Water Resources in cooperation with the Plumas National Forest. Direction for this Evaluation is provided in FSM 2670 and current R-5 policy letters.

The Biological Assessment discusses the sensitive species likely to be in the project area. The list is thorough and complete. Further, the Biological Assessment points out that snowpack augmentation will only occur in those years when precipitation is at average or below. The anticipated effect of augmentation would be in a range of less than a 10 percent increase in snowpack. This increase in average depths is certainly well within range of natural fluctuations and is well below such recent peak snowpack years as 1982 and 1983. Populations of animals discussed on National Forest lands have evolved with fluctuations much greater than the 10 percent of variance proposed herein.

In reviewing the recommendations presented by the Department of Water Resources in their Biological Assessment, Mr. Ratcliff found adequate protection measures for sensitive species proposed. Provision for monitoring has been made. Provision for avoidance of interruption of critical nesting and breeding seasons has been made.

The EIR/EIS documents the surveys for sensitive plants that were conducted in 1988 (pages 56 to 57). None of the dispenser sites proposed for this project contain sensitive plants. No ground disturbance to sensitive plant locations will occur as a results of the project. Again, the minor deviation in moisture regime is well within the tolerance range of site adapted plants.

Mr. Ratcliff has determined that this project with accompanying management recommendations will have no effect on any sensitive species, plant or animal, within the project area. Further, this project will have no effect on the Plumas N.F. Spotted Owl viability network.

The Biological Assessment is incorporated into this Biological Evaluation and all recommendations. Mr. Ratcliff states that the project should be allowed to proceed as planned upon compliance with other regulations and permit requirements as outlined by the Forest Supervisor.

ISSUE 4. A further analysis needs to be made on the potential effects of flooding on small streams. (Appeal Item 7).

DIRECTION

Since flooding problems are a concern, the suspension criteria needs to be validated. Supplement the EIS by determining the recurrence intervals for a storm that produces 4 inches of rain at Quincy, 5 inches of rain at La Porte, and the 60,000 cfs inflow into Lake Oroville. These data will tell if these rainfall and runoff events are extreme or common. If they are a common occurrence, then the flooding concern should be alleviated. If these events are extreme events, then the Forest Supervisor should evaluate the appropriateness of the suspension criteria.

DISCUSSION

It should first be mentioned that certain meteorological criteria have to be met before seeding will be initiated. Of most importance is the temperature both at the propane dispenser sites and at the 5,000 foot elevation zone. Seeding will not be conducted if the temperature at the dispensers sites is above -2 C or rain is falling at the 5,000 foot elevation. This criteria alone will preclude seeding during the warm storm events which historically produce the largest floods. In addition to this, however, suspension criteria have been established to further avoid seeding during potential flood situations.

The EIR/EIS provided a list of suspension criteria that are invoked when heavy precipitation periods and subsequent high streamflow events are expected. Specifically the criteria state that seeding would be suspended when precipitation (rain or snow water equivalent) of 4 inches in 24 hours, 5 in 48 hours or 6 inches in 72 hours at Quincy, CA is predicted or observed (via hourly telemetered data) to occur. Quantitative precipitation forecasts for Quincy are based on a numerical model developed to predict precipitation over mountain barriers and calibrated using empirical data from the Feather River watershed (Rhea 1986). If Quincy is unavailable the gauge at LaPorte would be used. The criteria for LaPorte are 5 inches in 24 hours, 6 inches in 48 hours or 7 inches in 72 hours. In addition to these criteria, predicted or observed inflow to Oroville Reservoir exceeding 60,000 cfs would also suspend project operations. These criteria were chosen based on long term historical records indicating that if seeding were suspended using these conservative threshold values, contributions to potential flooding situations via seeding would be all but eliminated.

Figure 12 is a plot showing the return interval of various 24 hour precipitation amounts at Quincy based on the period of record 1898 to 1982 (period of record available from the National Climatic Data Center). The graph shows that the 4 inches in 24 hours has a return interval of about 2.5 years. Stated another way, there is a 40 percent chance that one 24 hour period having 4 inches of precipitation will occur in a given year. Figure 13 shows the same diagram for LaPorte. Although the period of record is much shorter (1959 to 1976) the return interval for 5 inches in 24 hours is about every two years, much like Quincy. Figure 14 is a similar diagram for peak flows for the Feather River at Oroville. Here the period of record is 1881 to 1985. Both the return interval and probability of exceeding a given peak flow in a given year are shown. The 60,000 cfs peak flow has a return interval of one event every two years or a 50-50 chance of occurring in any given year. It can be concluded that the threshold levels chosen for the suspension criteria are not rare events and would suspend seeding well before damaging flooding occurs.

A similar snowpack augmentation project operated by the U. S. Bureau of Reclamation (Sierra Cooperative Pilot Project) on the American watershed for over ten years (1976 to 1987) utilized very similar suspension criteria. In every serious precipitation or high streamflow event that occurred, seeding was suspended often

Figure 12. Return interval for precipitation within a 24 hour period at Quincy, Cal.

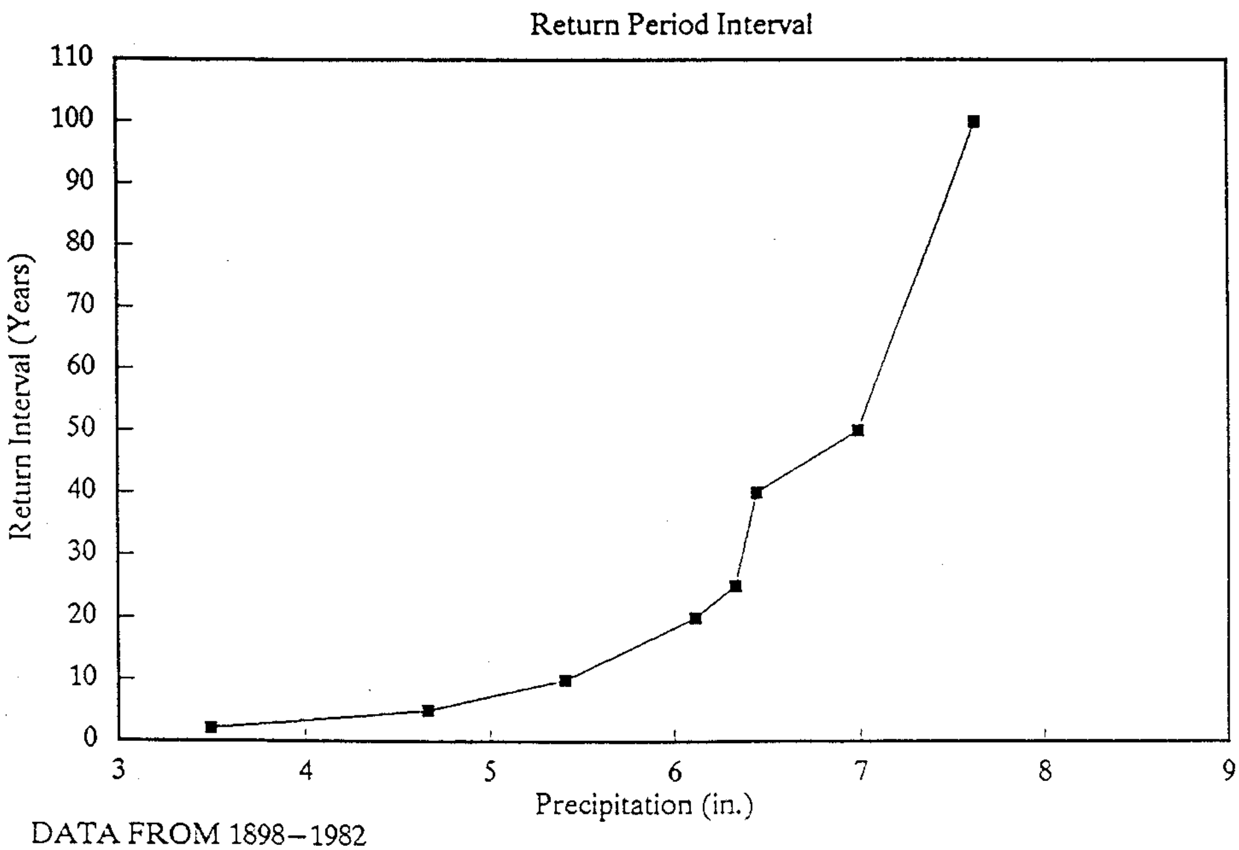
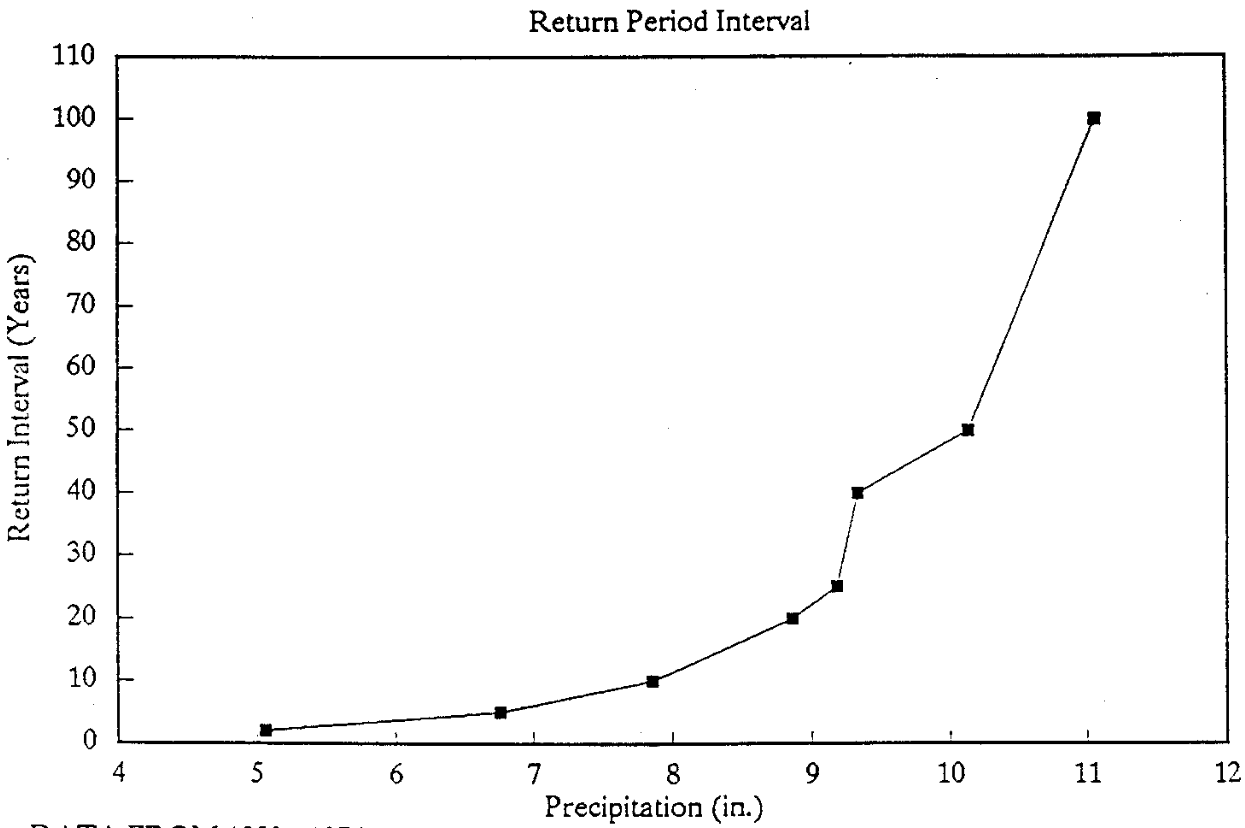
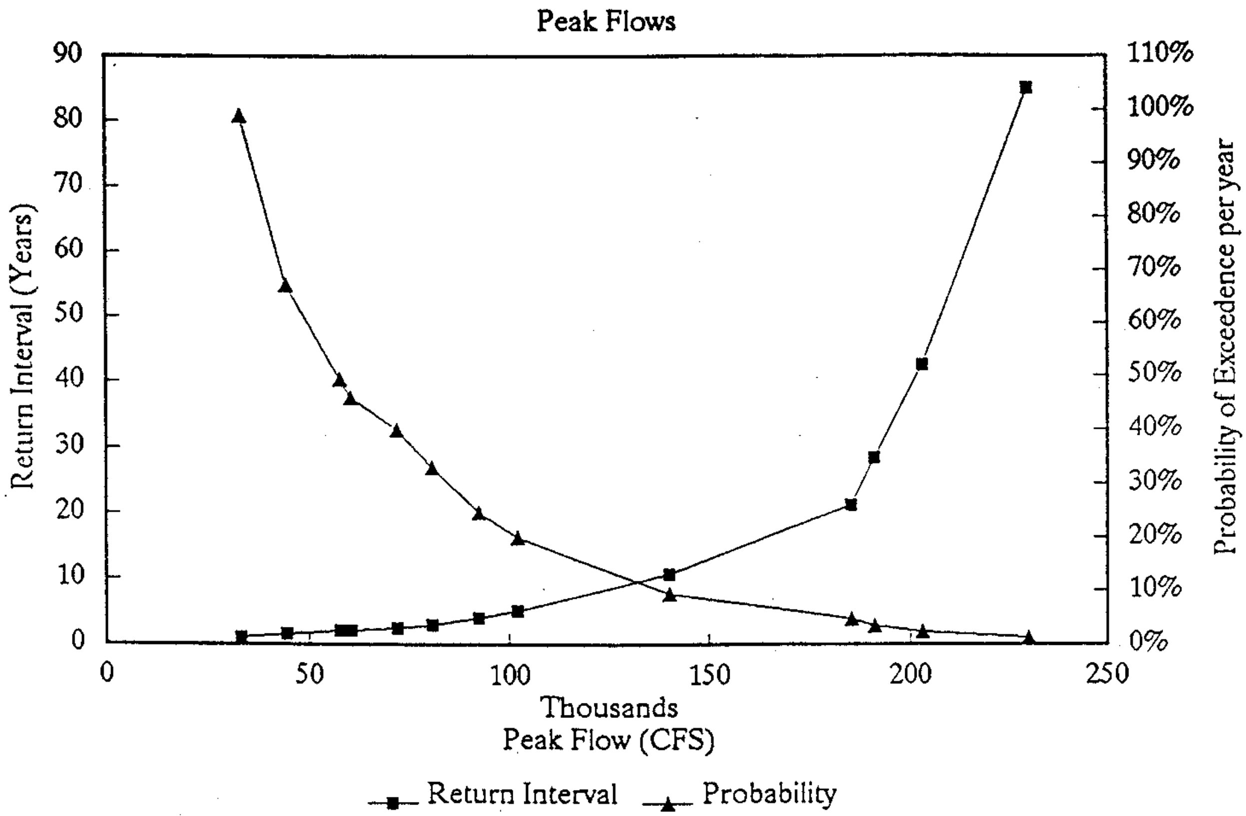


Figure 13. Return interval for precipitation within a 24 hour period at LaPorte, Cal.



DATA FROM 1959–1976

Figure 14. Return intervals for peak flows in the Feather River at Oroville, Cal.



Data from 1881–1985

several days before flooding became a problem. It is anticipated that this five year project will be just as successful in avoiding seeding during potentially hazardous situations.

ISSUE 5. Identify if there are any municipal supply watersheds within the project area, and, if so, the effects of the project on water quality in these watersheds. (Appeal Item 8a).

DIRECTION

Since the EIS does not mention domestic water uses, supplement the EIS by reviewing the Forest Land Management Plan to determine if any municipal supply watersheds are in the project area. If there are municipal supply watersheds present, then discuss how this project meets the Forest Plan standards and guidelines.

DISCUSSION

Seventeen domestic water supply systems (i.e., greater than five hookups) occur within the cloud seeding project area (Table 13). These systems supply water for domestic use to approximately 2,700 customers and range in size from 5 to 1,800 hookups.

Sixty-four percent of these water systems rely exclusively upon ground water sources, including Western Pacific Railroad, Grizzly Lake Resort Improvement District, Middle Fork Trailer Park, Plumas-Eureka State Park, Cromberg Springs Associates, Golden Coach Trailer Park, Feather River Lumber Company and Sloate Water System. Twenty-four percent use both surface and ground water sources. Water purveyors using these hybrid systems include City of Portola, Plumas-Eureka Estates, Layman Bar Summer Home Tract, and Spring Garden. Twelve percent of the systems use only surface water sources, including Graeagle Water Company and Blairsden Water Users Association.

This project is expected to meet Plumas National Forest Plan guidelines, which are to "keep water quality at a level that will allow a safe and satisfactory supply when given reasonable treatment by the purveyor."

The EIS/EIR projected no impact to water quality, assuming no significant increase in erosion rates. The EIS/EIR further projects that enhanced runoff will not significantly increase erosion within the project watershed. The quality of water is not expected to be degraded (see CWE analysis). One of the principal environmental advantages of using propane for cloud seeding purposes is that the precipitation formed from propane contains no contaminants (unlike seeding with silver iodide). The pilot project will not contribute contaminants to the watershed. Although input of chemical constituents will not increase over natural levels, chemical weathering may increase total dissolved solids output. Increased quantity of water leaving the watershed, however, should dilute the total dissolved levels to

Table 13. Domestic Water Systems Within the Cloud Seeding Project Area (5 or more hookups)

Water System	No. of Hookups	Source	Drainage Area (acres) of Surface Water Sources
City of Portola	1,800	Spring & S.W.	Willow Cr. & Lake Davis (30,670)
Western Pacific Railroad	10	Wells	
Grizzly Lake Resort Improvement Dist.	90	Spring	
Clio Public Utility District	24	Spring	
Graeagle Water Company	538	S.W.	Graeagle Creek (4,704)
Blairsden Water Users Association	30	S.W.	Bonta Creek (2,490)
Middle Fork Trailer Park	11	Wells	
Plumas-Eureka State Park	?	Spring-Wells	
Johnsville Public Utility District	28	Spring	
Plumas-Eureka Estates	130	Spring & S.W.	Jamison Creek (12,942)
Two Rivers Resort	5	Spring	
Layman Bar Summer Home Tract	14	Spring & S.W.	Cub Creek (1,300)
Cromberg Spring Associates	10	Spring	
Golden Coach Trailer Park	16	Well	
Feather River Lumber Company	20	Well	
Sloate Water System	12	Well	
Spring Garden	11	Spring & S.W.	Estray Creek (3,120)

concentrations at or below preproject levels.

The cloud seeding pilot program is not expected to alter water quality from existing safe levels. Summer water supplies may be increased slightly due to higher ground water levels.

ISSUE 6. Assure that the California Department of Fish and Game, and the U.S. Fish and Wildlife Service are consulted on this project. (Appeal Item 6b).

DIRECTION

Since it is not clear what documents were received by the Department of Water Resources, supplement the EIS with 1) the procedure that the Department of Water Resources used in consulting with the California Department of Fish and Game and U. S. Fish and Wildlife Service, and 2) any written responses obtained from these agencies.

DISCUSSION

Both the Department of Fish and Game and U. S. Fish and Wildlife Service received copies of the draft EIS/EIR. Neither agency chose to comment on any portion of the draft EIS/EIR.

Specialists from both agencies were contacted during the development of the Biological Assessment to provide information or opinions on species specific impacts associated with the proposed cloud seeding program. No written communication from either agency has been received.

V. LIST OF PREPARERS

This supplement to the Environmental Impact Statement for the Prototype Project to Augment Snowpack by Cloud Seeding Using Ground Based Dispensers in Plumas and Sierra Counties was prepared by the California Department of Water Resources in coordination with the Plumas National Forest, and the U. S. Bureau of Reclamation s Division of Atmospheric Resources Research in Denver, Colorado.

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VII. APPENDICES

APPENDIX A Current and Projected Equivelent Roaded Acre Assessments

Table A-1. Current Equivelent Roaded Acre Assessment for the Squirrel Creek Watershed.

Land Use Activity	Area (acres)	Land Disturbance Coefficient	ERA Value	Recovery Coefficient	Current ERA Value
Roading	195.8	1.00	195.8	1.00	195.8
Timber Harvest					
Public Lands	0.0	0.00	0.0	0.00	0.0
Private Lands					
1989	160.0	0.20	32.0	0.97	31.0
1990	40.0	0.20	8.0	0.99	7.9
Mining	1.0	1.00	1.0	1.00	1.0
Grazing	100.0	0.01	1.0	1.00	1.0
Wildfire	0.0	0.00	0.0	0.00	0.0
Subtotal	5218.0				236.7
Existing ERA Values					
Unit F	2100.0				6.0
Above Subtotal	5218.0				4.5
Total	7318.0			ERA	4.9
				TOC	12.0
				% of TOC	37.4

Table A-2. Current Equivelent Roaded Acre Assessment for the Greenhorn Creek Watershed.

Land Use Activity	Area (acres)	Land Disturbance Coefficient	ERA Value	Recovery Coefficient	Current ERA Value
Roading	166.5	1.00	166.5	1.00	166.5
Timber Harvest					
Public Lands	0.0	0.00	0.0	0.00	0.0
Private Lands					
1982	405.0	0.20	81.0	0.50	40.5
1982	405.0	0.20	81.0	0.50	40.5
Mining	0.0	0.00	0.0	0.00	0.0
Grazing	300.0	0.05	3.0	1.00	3.0
Wildfire	0.0	0.00	0.0	0.00	0.0
Subtotal	3626.0				250.7
Existing ERA Values					
Unit E	1450.0				8.5
Unit D	1660.0				4.0
Above Subtotal	3626.0				6.9
Total	6736.0			ERA	6.5
				TOC	12.0
				% of TOC	54.2

Table A-3. Current Equivelent Roaded Acre Assessment for the Estray Creek Watershed.

Land Use Activity	Area (acres)	Land Disturbance Coefficient	ERA Value	Recovery Coefficient	Current ERA Value
Roading	202.5	1.00	202.5	1.00	202.5
Timber Harvest					
Public Lands					
Salvage	207.0	0.06	12.4	0.97	12.0
Private Lands					
1989	150.0	0.20	30.0	0.97	29.1
1990	175.0	0.20	35.0	0.99	34.7
Mining	0.0	0.00	0.0	0.00	0.0
Grazing	0.0	0.00	0.0	0.00	0.0
Wildfire	112.0	0.40	44.8	0.97	43.5
	380.0	0.15	57.0	0.97	55.3
Subtotal	6109.0				377.1
Existing ERA Values					
Subwatershed A	1550.0				7.0
Subwatershed B+C	1980.0				3.0
Above Subtotal	6109.0				6.2
Total	9639.0			ERA	5.7
				TOC	10.0
				% of TOC	57.0

Table A-4. Current Equivelent Roaded Acre Assessment for the Willow Creek Watershed.

Land Use Activity	Area (acres)	Land Disturbance Coefficient	ERA Value	Recovery Coefficient	Current ERA Value
Roading	475.2	1.00	475.2	1.00	475.2
Timber Harvest					
Public Lands					
1986	454.0	0.35	158.9	0.96	152.5
1986	29.0	0.20	5.8	0.90	5.2
Private Lands					
1984	13.0	0.20	2.6	0.72	1.9
1986	598.0	0.20	119.6	0.83	99.2
1989	210.0	0.20	42.0	0.97	40.7
Mining	0.0	0.00	0.0	0.00	0.0
Grazing	1200.0	0.02	24.0	1.00	24.0
Wildfire	0.0	0.00	0.0	0.00	0.0
Subtotal	13145.0				798.7
Existing ERA Values					
Humbug Salvage	853.0				8.5
Above Subtotal	13145.0				6.0
Total	13998.0			ERA	6.2
				TOC	11.0
				% of TOC	56.3

Table A-5. Current Equivelent Roaded Acre Assessment for the Nelson Creek Watershed.

Land Use Activity	Area (acres)	Land Disturbance Coefficient	ERA Value	Recovery Coefficient	Current ERA Value
Roading	346.2	1.00	346.2	1.00	346.2
Timber Harvest					
Public Lands	0.0	0.00	0.0	0.00	0.0
Private Lands	0.0	0.00	0.0	0.00	0.0
Mining	12.0	1.00	12.0	1.00	12.0
Grazing	0.0	0.00	0.0	0.00	0.0
Wildfire	0.0	0.00	0.0	0.00	0.0
Subtotal	26828.0				358.2
Existing ERA Values					
Fish Creek	680.0				2.0
Coldwater Creek	1340.0				2.5
Gambini Creek	190.0				2.0
Poorman Creek	2058.0				7.2
Unit O	135.0				3.0
Unit P	170.0				12.0
Unit Q	300.0				1.0
Unit R	300.0				7.5
Gambini E	640.0				6.0
Above Subtotal	26828.0				1.3
Total	32641.0			ERA	2.0
				TOC	6.0
				% of TOC	33.3

Table A-6. Current Equivelent Roaded Acre Assessment for the Poplar Creek Watershed.

Land Use Activity	Area (acres)	Land Disturbance Coefficient	ERA Value	Recovery Coefficient	Current ERA Value
Roading	155.2	1.00	155.2	1.00	155.2
Timber Harvest					
Public Lands	0.0	0.00	0.0	0.00	0.0
Private Lands	0.0	0.00	0.0	0.00	0.0
Mining	35.0	1.00	35.0	1.00	35.0
Grazing	640.0	0.01	6.4	1.00	6.4
Wildfire	0.0	0.00	0.0	0.00	0.0
Subtotal	5374.0				196.6
Existing ERA Values					
Unit AA	660.0				1.0
Unit E	590.0				0.0
Unit W	380.0				1.0
Unit I	530.0				13.0
Unit J	200.0				0.5
Unit K	680.0				4.0
Unit F	240.0				0.0
Unit G	680.0				0.0
Above Subtotal	5374.0				3.7
Total	9334.0			ERA	3.3
				TOC	12.0
				% of TOC	27.5

Table A-7. Current Equivelent Roaded Acre Assessment for the Jamison Creek Watershed.

Land Use Activity	Area (acres)	Land Disturbance Coefficient	ERA Value	Recovery Coefficient	Current ERA Value
Roading	470.7	1.00	470.7	1.00	470.7
Timber Harvest					
Public Lands	0.0	0.00	0.0	0.00	0.0
Private Lands					
1981	110.0	0.20	22.0	0.50	11.0
Mining	20.0	1.00	20.0	1.00	20.0
Grazing	450.0	0.10	45.0	1.00	45.0
Wildfire	0.0	0.00	0.0	0.00	0.0
Subtotal	18092.0				525.7
Existing ERA Values					
Unit L	660.0				3.0
Unit M	730.0				10.0
Unit N	530.0				1.5
Above Subtotal	18092.0				2.9
Total	20012.0			ERA	3.1
				TOC	9.0
				% of TOC	34.4

Table A-8. Current Equivelent Roaded Acre Assessment for the Graeagle Creek Watershed.

Land Use Activity	Area (acres)	Land Disturbance Coefficient	ERA Value	Recovery Coefficient	Current ERA Value
Roading	135.4	1.00	135.4	1.00	135.4
Timber Harvest					
Public Lands	0.0	0.00	0.0	0.00	0.0
Private Lands	0.0	0.00	0.0	0.00	0.0
Mining	5.0	1.00	5.0	1.00	5.0
Grazing	640.0	0.02	12.8	1.00	12.8
Wildfire	0.0	0.00	0.0	0.00	0.0
Subtotal	5814.0				153.2
Total	5814.0			ERA	2.6
				TOC	12.0
				% of TOC	21.6

Table A-9. Current Equivelent Roaded Acre Assessment for the Sulphur Creek Watershed.

Land Use Activity		Area (acres)	Land Disturbance Coefficient	ERA Value	Recovery Coefficient	Current ERA Value
Roading		664.4	1.00	664.4	1.00	664.4
Timber Harvest						
Public Lands						
		86.0	0.40	34.4	0.87	29.9
		150.0	0.20	30.0	0.87	26.1
		21.0	0.40	8.4	0.94	7.9
Private Lands						
	1981	15.0	0.20	3.0	0.68	2.0
	1981	598.0	0.20	119.6	0.68	81.3
	1984	40.0	0.40	16.0	0.90	14.4
	1984	61.0	0.20	3.2	0.80	2.6
	1984	510.0	0.20	102.0	0.80	81.6
Mining		35.0	1.00	35.0	0.80	28.0
Grazing		14516.0	0.02	290.3	1.00	290.3
Wildfire		0.0	0.00	0.0	0.00	0.0
Subtotal		13926.0				1228.5
Existing ERA Values						
Unit A		960.0				4.5
Unit B		340.0				9.5
Unit C		710.0				5.5
Unit D		460.0				8.5
Unit E		1110.0				7.0
Unit F		300.0				6.5
Unit G		470.0				6.0
Unit H		870.0				7.0
Unit S-A		1900.0				8.0
Unit S-B		470.0				9.0
Unit S-C		700.0				3.0
Unit S-D		275.0				8.0
Above Subtotal		13926.0				8.8
Total		22491.0			ERA	8.0
					TOC	9.0
					% of TOC	88.8

Table A-10. Projected Equivelent Roaded Acre Assessment for the Squirrel Creek Watershed

Land Use Activity	Area (acres)	Land Disturbance Coefficient	ERA Value	Recovery Coefficient	Projected ERA Value
Roading	195.8	1.00	195.8	1.00	199.3
Timber Harvest					
Public Lands	254.0	0.35	88.9	1.00	88.9
	633.3	0.20	126.6	1.00	126.6
Private Lands					
1989	160.0	0.20	32.0	0.65	20.8
1990	40.0	0.20	8.0	0.80	6.4
Projected	3156.0	0.075	118.8	1.00	118.8
Mining	1.0	1.00	1.0	1.00	1.0
Grazing	100.0	0.10	10.0	1.00	10.0
Wildfire	0.0	0.00	0.0	0.00	0.0
Subtotal	5218.0				571.8
Projected ERA Values					
Subwatershed F	2100.0				6.0
Above Subtotal	5218.0				10.9
Total	7318.0			ERA	9.5
				TOC	10.0
				% of TOC	95.0

Table A-11. Projected Equivelent Roaded Acre Assessment for the Greenhorn Creek Watershed

Land Use Activity	Area (acres)	Land Disturbance Coefficient	ERA Value	Recovery Coefficient	Projected ERA Value
Roading	166.5	1.00	166.5	1.00	168.6
Timber Harvest					
Public Lands	114.0	0.35	39.9	1.00	39.9
	283.3	0.20	56.7	1.00	56.7
Private Lands					
1982	405.0	0.20	81.0	0.30	24.3
1982	405.0	0.20	81.0	0.30	24.3
Projected	2151.0	0.075	80.9	1.00	80.9
Mining	0.0	0.00	0.0	0.00	0.0
Grazing	300.0	0.10	30.0	1.00	30.0
Wildfire	0.0	0.00	0.0	0.00	0.0
Subtotal	3626.0				424.7
Existing ERA Values					
Subwatershed E	1450.0				8.5
Subwatershed D	1660.0				4.0
Above Subtotal	3626.0				11.7
Total	6736.0			ERA	9.1
				TOC	10.0
				% of TOC	91.0

Table A-12. Projected Equivelent Roaded Acre Assessment for the Estray Creek Watershed

Land Use Activity	Area (acres)	Land Disturbance Coefficient	ERA Value	Recovery Coefficient	Projected ERA Value
Roading	203.5	1.00	203.5	1.00	203.5
Timber Harvest					
Public Lands	33.0	0.35	11.6	1.00	11.6
	83.3	0.20	16.7	1.00	16.7
Salvage	207.0	0.06	12.4	0.65	8.1
Private Lands					
1989	150.0	0.20	30.0	0.65	19.5
1990	175.0	0.20	35.0	0.70	24.5
Projected	5177.0	0.038	194.9	1.00	194.9
Mining	0.0	0.00	0.0	0.00	0.0
Grazing	0.0	0.00	0.0	0.00	0.0
Wildfire	112.0	0.40	44.8	0.60	26.9
	380.0	0.15	57.0	0.60	34.2
Subtotal	6109.0				539.9
Projected ERA Values					
Subwatershed A	1550.0				7.0
Subwatershed B+C	1980.0				3.0
Above Subtotal	6109.0				8.8
Total	9639.0			ERA	7.3
				TOC	10.0
				% of TOC	73.0

Table A-13. Projected Equivelent Roaded Acre Assessment for the Willow Creek Watershed

Land Use Activity	Area (acres)	Land Disturbance Coefficient	ERA Value	Recovery Coefficient	Projected ERA Value
Roading	475.2	1.00	475.2	1.00	475.2
Timber Harvest					
Public Lands					
1986	454.0	0.35	158.9	0.68	108.1
1986	29.0	0.20	5.8	0.50	2.9
Private Lands					
1984	13.0	0.20	2.6	0.48	1.2
1986	598.0	0.20	119.6	0.52	62.2
1989	210.0	0.20	42.0	0.70	29.4
Projected	3883.0	.038	146.2	1.00	146.2
Mining	0.0	0.00	0.0	0.00	0.0
Grazing	1200.0	0.10	120.0	1.00	120.0
Wildfire	0.0	0.00	0.0	0.00	0.0
Subtotal	13145.0				945.2
Projected ERA Values					
Humbug Salvage	853.0				8.5
Above Subtotal	13145.0				7.2
Total	13998.0			ERA	7.3
				TOC	9.0
				% of TOC	81.1

Table A-14. Projected Equivelent Roaded Acre Assessment for the Nelson Creek Watershed

Land Use Activity	Area (acres)	Land Disturbance Coefficient	ERA Value	Recovery Coefficient	Projected ERA Value
Roading	346.6	1.00	346.6	1.00	346.6
Timber Harvest					
Public Lands	30.0	0.35	10.5	1.00	10.5
	75.0	0.20	15.0	1.00	15.0
Private Lands	553.9	0.038	20.9	1.00	20.9
Mining	12.0	1.00	12.0	1.00	12.0
Grazing	0.0	0.00	0.0	0.00	0.0
Wildfire	0.0	0.00	0.0	0.00	0.0
Subtotal	26828.0				405.0
Projected ERA Values					
Fish Creek	680.0				2.0
Coldwater Creek	1340.0				2.5
Gambini Creek	190.0				2.0
Poorman Creek	2058.0				7.2
Subwatershed O	135.0				3.0
Subwatershed P	170.0				12.0
Subwatershed Q	300.0				1.0
Subwatershed R	300.0				7.5
Gambini East	640.0				6.0
Above Subtotal	26828.0				1.5
Total	32641.0			ERA	2.1
				TOC	8.0
				% of TOC	26.3

Table A-15. Projected Equivelent Roaded Acre Assessment for the Poplar Creek Watershed

Land Use Activity	Area (acres)	Land Disturbance Coefficient	ERA Value	Recovery Coefficient	Projected ERA Value
Roading	156.6	1.00	156.6	1.00	156.6
Timber Harvest					
Public Lands	90.0	0.35	31.5	1.00	31.5
	225.0	0.20	45.0	1.00	45.0
Private Lands	5239.8	0.038	197.3	1.00	197.3
Mining	35.0	1.00	35.0	1.00	35.0
Grazing	640.0	0.10	64.0	1.00	64.0
Wildfire	0.0	0.00	0.0	0.00	0.0
Subtotal	5374.0				529.4
Projected ERA Values					
Subwatershed AA	660.0				1.0
Subwatershed E	590.0				0.0
Subwatershed W	380.0				1.0
Subwatershed I	530.0				13.0
Subwatershed J	200.0				0.5
Subwatershed K	680.0				4.0
Subwatershed F	240.0				0.0
Subwatershed G	680.0				0.0
Above Subtotal	5374.0				9.9
Total	9334.0			ERA	6.8
				TOC	10.0
				% of TOC	68.0

Table A-16. Projected Equivelent Roaded Acre Assessment for the Jamison Creek Watershed

Land Use Activity	Area (acres)	Land Disturbance Coefficient	ERA Value	Recovery Coefficient	Projected ERA Value
Roading	470.7	1.00	470.7	1.00	470.7
Timber Harvest					
Public Lands	0.0	0.00	0.0	0.00	0.0
Private Lands					
1981	110.0	0.20	22.0	0.20	4.4
Projected	935.9	0.038	35.2	1.00	35.2
Mining	20.0	1.00	20.0	1.00	20.0
Grazing	450.0	0.10	45.0	1.00	45.0
Wildfire	0.0	0.00	0.0	0.00	0.0
Subtotal	18092.0				575.3
Projected ERA Values					
Subwatershed L	660.0				3.0
Subwatershed M	730.0				10.0
Subwatershed N	530.0				1.5
Above Subtotal	18092.0				3.1
Total	20012.0			ERA	3.3
				TOC	9.0
				% of TOC	36.7

Table A-17. Projected Equivelent Roaded Acre Assessment for the Graeagle Creek Watershed

Land Use Activity	Area (acres)	Land Disturbance Coefficient	ERA Value	Recovery Coefficient	Projected ERA Value
Roading	135.4	1.00	135.4	1.00	135.4
Timber Harvest					
Public Lands	0.0	0.00	0.0	0.00	0.0
Private Lands	795.6	0.038	30.0	1.00	30.0
Mining	5.0	1.00	5.0	1.00	5.0
Grazing	350.0	0.10	35.0	1.00	35.0
Wildfire	0.0	0.00	0.0	0.00	0.0
Subtotal	5814.0				205.4
Total	5814.0			ERA	3.5
				TOC	10.0
				% of TOC	35.0

Table A-18. Projected Equivelent Roaded Acre Assessment for the Sulphur Creek Watershed

Land Use Activity	Area (acres)	Land Disturbance Coefficient	ERA Value	Recovery Coefficient	Projected ERA Value
Roading	664.4	1.00	664.4	1.00	664.4
Timber Harvest					
Public Lands					
	86.0	0.40	34.4	0.57	19.6
	150.0	0.20	30.0	0.35	10.5
	21.0	0.40	8.4	0.73	6.1
Private Lands					
1981	15.0	0.20	3.0	0.20	0.6
1981	598.0	0.20	119.6	0.20	23.9
1984	40.0	0.40	16.0	0.67	10.7
1984	61.0	0.20	3.2	0.57	1.8
1984	510.0	0.20	102.0	0.57	58.1
Projected	10468.9	0.038	394.2	1.00	394.2
Mining	35.0	1.00	35.0	1.00	35.0
Grazing					
Public Lands	2400.0	0.05	120.0	1.00	120.0
Private Lands	878.6	0.10	87.9	1.00	87.9
Wildfire	0.0	0.00	0.0	0.00	0.0
Subtotal	13926.0				1432.8
Existing ERA Values					
Subwatershed A	960.0				4.5
Subwatershed B	340.0				9.5
Subwatershed C	710.0				5.5
Subwatershed D	460.0				8.5
Subwatershed E	1110.0				7.0
Subwatershed F	300.0				6.5
Subwatershed G	470.0				6.0
Subwatershed H	870.0				7.0
Subwatershed S-A	1900.0				8.0
Subwatershed S-B	470.0				9.0
Subwatershed S-C	700.0				3.0
Subwatershed S-D	275.0				8.0
Above Subtotal	13926.0				10.2
Total	22491.0			ERA	8.9
				TOC	9.0
				% of TOC	98.9

Table A-19. Projected Equivelent Roaded Acre Assessment for the Long Valley Creek Watershed.

Land Use Activity	Area (acres)	Land Disturbance Coefficient	ERA Value	Recovery Coefficient	Current ERA Value
Roading	0.6	1.00	0.6	1.00	0.6
Timber Harvest					
Public	40.0	0.35	14.0	1.00	14.0
	100.0	0.20	20.0	1.00	20.0
Private	4594.0	0.03765	172.9	1.00	172.9
Existing ERA Values					
Subwatershed A	1660.0				10.0
Subwatershed B	1870.0				16.0
Subwatershed C	690.0				8.0
Subwatershed D	580.0				11.5
Subwatershed E	780.0				11.0
Subwatershed F	1470.0				9.4
Lower Watershed	2880.0				9.5
Total	9930.0			ERA	12.6
				TOC	12.0
				% of TOC	104.9

Table A-20. Projected Equivelent Roaded Acre Assessment for the Consignee Creek Watershed.

Land Use Activity	Area (acres)	Land Disturbance Coefficient	ERA Value	Recovery Coefficient	Current ERA Value
Roading	30.0	1.00	3.0	1.00	30.0
Timber Harvest					
Public Lands	49.2	0.03765	1.85	1	1.85
1986	12.0	0.35	4.2	0.80	3.4
1986	8.0	0.20	1.6	0.80	1.3
1990	210.0	0.25	52.5	0.60	31.5
1990	67.0	0.65	43.6	0.47	20.4
Private Lands	0.0	0.00	0.0	0.00	0.0
Mining	10.0	0.30	3.0	1.00	3.0
Grazing	0.0	0.00	0.0	0.00	0.0
Wildfire	190.0	0.20	38.0	0.40	15.2
	217.0	0.50	109.0	0.40	43.6
Subtotal	1330.0				150.3
Total	1330.0			ERA	11.3
				TOC	12.0
				% of TOC	94.2

Table A-21. Projected Equivelent Roaded Acre Assessment for the Little Long Valley Creek Watershed.

Land Use Activity	Area (acres)	Land Disturbance Coefficient	ERA Value	Recovery Coefficient	Current ERA Value
Timber Harvest					
Private	2720.7	0.03765	102.4	1.00	102.4
Existing ERA Values					
Subwatershed A	1260.0				9.5
Subwatershed B	690.0				10.6
Subwatershed C	670.0				10.0
Lower Watershed	1160.0				8.6
Total				ERA	9.8
				TOC	12.0
				% of TOC	81.6

Table A-22. Projected Equivelent Roaded Acre Assessment for the Rattlesnake Creek Watershed.

Land Use Activity	Area (acres)	Land Disturbance Coefficient	ERA Value	Recovery Coefficient	Current ERA Value
Timber Harvest					
Private Lands	543.7	0.03765	20.5	1.00	20.5
Existing ERA Values					
Subwatershed 53	1050.0				7.5
Subwatershed 54	1070.0				9.5
	2120.0				
Total	2120.0			ERA	8.6
				TOC	12.0
				% of TOC	71.6

APPENDIX B - RAIN ON SNOW MODEL DESCRIPTION

This information addresses the concerns made in the appeal (Item 3b) relating to the direct, indirect and cumulative effects of snowpack augmentation (assumed 10 percent increase), if early snowmelt (assumed to be caused by warm rain on snow) occurred, on landslides, channel aggradation and degradation, and bank erosion. The information below is in addition to what was provided on pages 48 and 49 of the Final EIS under Section IV-F-7, Runoff and Floods.

A large body of information exists about the hydrologic response of a rain on snow event (Bergman 1983, Kattleman 1986). As stated by Kattleman "The rate of meltwater production in years of average snowpacks is essentially independent of the amount of snow on the ground. Similarly, rain on snow events, which are responsible for the highest peak flows and occasional mass movements, would be unaffected by changes in snowpack depth due to weather modification. Only in the transient snow zone would small changes in snowpack depth affect erosion processes. Here if weather modification resulted in a thin snow cover on ground that would otherwise have been bare, melt during rainfall would lead to greater runoff than would have occurred naturally. Conversely, the shallow snow cover made possible by weather modification would protect the soil from raindrop impact and minimize surface erosion." As these results were determined for the American and Yuba basins it is necessary to determine if the same conclusions hold for the Feather basin and specifically within the projected target area. Modeling for the Feather basin showed no increase in peak flow at different initial snow depths for 15 and 50-year storm events. The following data is presented in this regard.

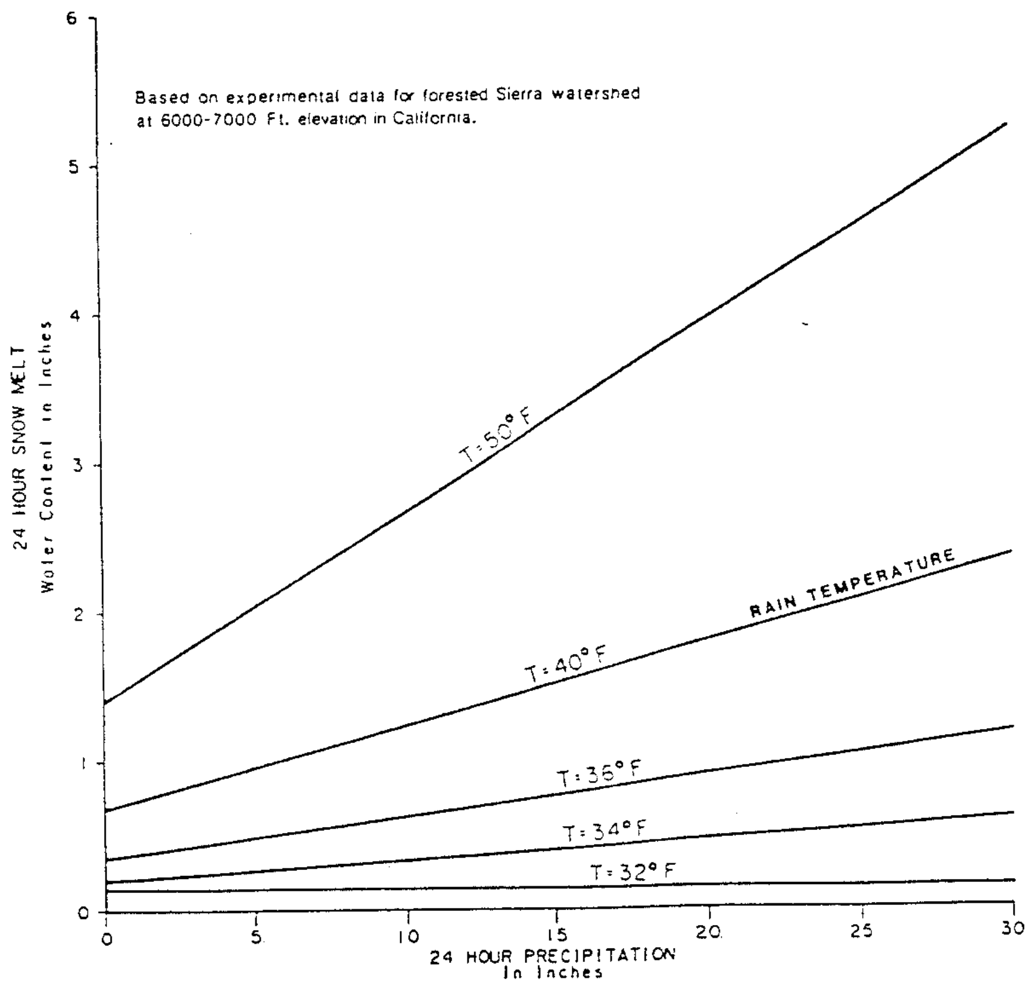
Rain on Snow Case Studies Within the Proposed Target Area

It takes a large amount of energy to melt snow. The U. S. Army Corps of Engineers has developed some empirical equations based upon conditions in the Central Sierra. These equations take into account rain, wind and heat from the ground in generating melt. Figure 15 shows 24 hour snowmelt for a forested area with rain ranging in temperature from 32 F to 50 F. For example, 10 inches of rain falling at 40 F will result in about 1.2 inches of water being released from the pack. Note that the figure also shows that with no rain falling, a temperature of 40 F will melt approximately 0.7 inches of snow water equivalent.

Both extensive research at the Central Sierra Snow Lab and field data from automated snow sensors (snow water content from snow pillows which is telemetered back to the Department of Water Resources in Sacramento) data indicate that rain on snow compresses and wets the snowpack but melts very little snow in comparison to the amount of rain that falls. For elevations above 5,500 feet, where the seasonal snowpack resides, data collected from rain on snow events such as the February 1986 and the March 1989 storms show the following.

February 1986 Case Study - During the middle of February 1986, a series of storms

Figure 15. Snowmelt versus rainfall and temperature based on experimental data for forested Sierra watersheds at 6,000 to 7,000 foot elevations.



SOURCE: STEIN BUER, HYDROLOGY AND WATER SUPPLY BRANCH, D.W.R.

passed through the Sierra Nevada, producing after ten days of precipitation, widespread flooding. This storm is significant in that it was proceeded by a somewhat below normal precipitation season to that point. This would be typical of a year when cloud seeding would have been conducted. The period of precipitation began late on February 11 and continued through February 20. However seeding would have been suspended on February 11 had this cloud seeding program been in existence due to the prediction of excessive rainfall (the Bureau of reclamation's Sierra Project being conducted at this time in the American River basin was suspended at noon on the 11th because of a prediction of 4 to 8 inches of precipitation over the next 48 hours). Given that the snow line was near or above 5,000 feet for these storms, pre-project criteria set-up for seed/no-seed decision making would not have been met.

Figures 16, 17 and 18 are graphs showing precipitation, snowpack water content and temperature (when available) for three stations in the Feather drainage. The two highest elevation stations, Gold Lake and Grizzly Ridge are in the proposed target area. Four Trees at 5,150 feet is on the west side of the Sierra and also has a much wetter climate than any station in the target area but is used as an example of elevations within the transient snow zone. Moving from west to east, Figure 16 shows data for Four Trees for this ten day period. The water equivalent of the pack started out at 1.5 inches on the 11th. The pack gained 2.5 inches of water during a fairly cold rain event in the first 36 hours. After a 24 hour break ten inches of rain fell at temperatures between 35 to 40 F yielding about 1.5 inches of water from the pack as Figure 15 would suggest. The major rainfall period began about 125 hours into the storm. Almost 30 inches of rain fell in a two day period. This melted the remaining 2 inches of water equivalent snow, again as Figure 15 would suggest.

Several important points must be made when discussing this data. First, only the original 1.5 inches of water equivalent in the pack as of February 11 is relevant to the discussion of snow augmentation and its impact. Assuming that the project would have produced an additional 10 percent increase in water content in the pack, only 0.15 inches of this 1.5 inches would have been due to seeding; much less than the 45 inches of rain that fell. It took 10 hours for the original 1.5 inches to melt or wash off. Therefore there would have been a contribution to the rise in the streamflow from seeding, but at a ratio of 0.15 inches/12 inches rain (that melted it) or 1.25 percent contribution. Secondly, this site is not truly representative of the target area in that Four Trees is much wetter and thus the transient snow zone in the proposed target area may have had less snow water equivalent and certainly, as will be shown in the following figures, much less rainfall to melt the snow.

Figure 17 shows the same information as Figure 16 but for Gold Lake, a site in the extreme western edge of the proposed target area and to the east of the Sierra crest. Note here the snowpack water equivalent started out at about 28 inches. As several major precipitation events occurred in the next ten days at temperatures near 40 F, the snowpack water equivalent increased or remained constant. By the end of the storm period the snowpack water equivalent had increased to almost 42 inches.

Figure 16. Hourly precipitation and temperature data collected at Four Trees, Cal. and LaPorte, Cal. respectively during the period of February 11 through 20, 1986.

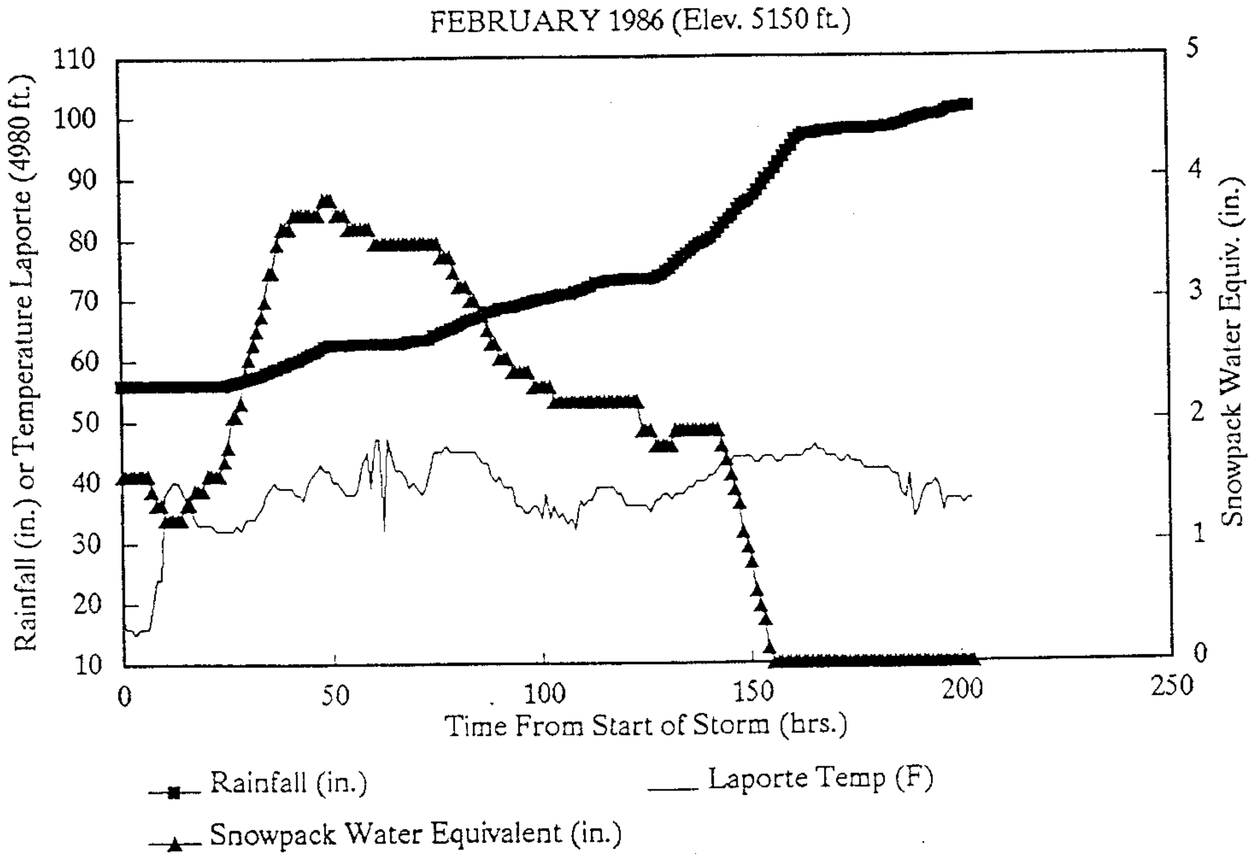


Figure 17. Hourly precipitation and temperature data collected at Gold Lake, Cal. for the period of February 11 through 20, 1986.

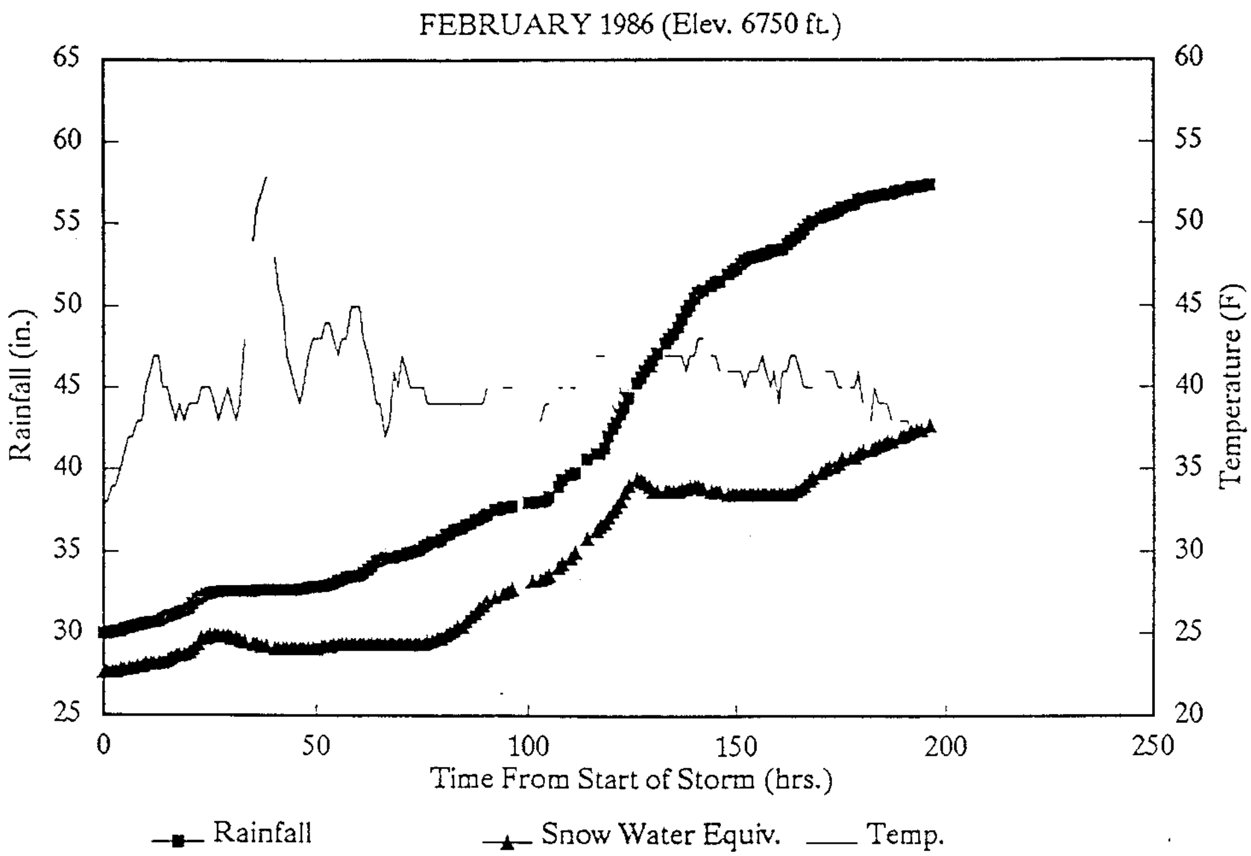
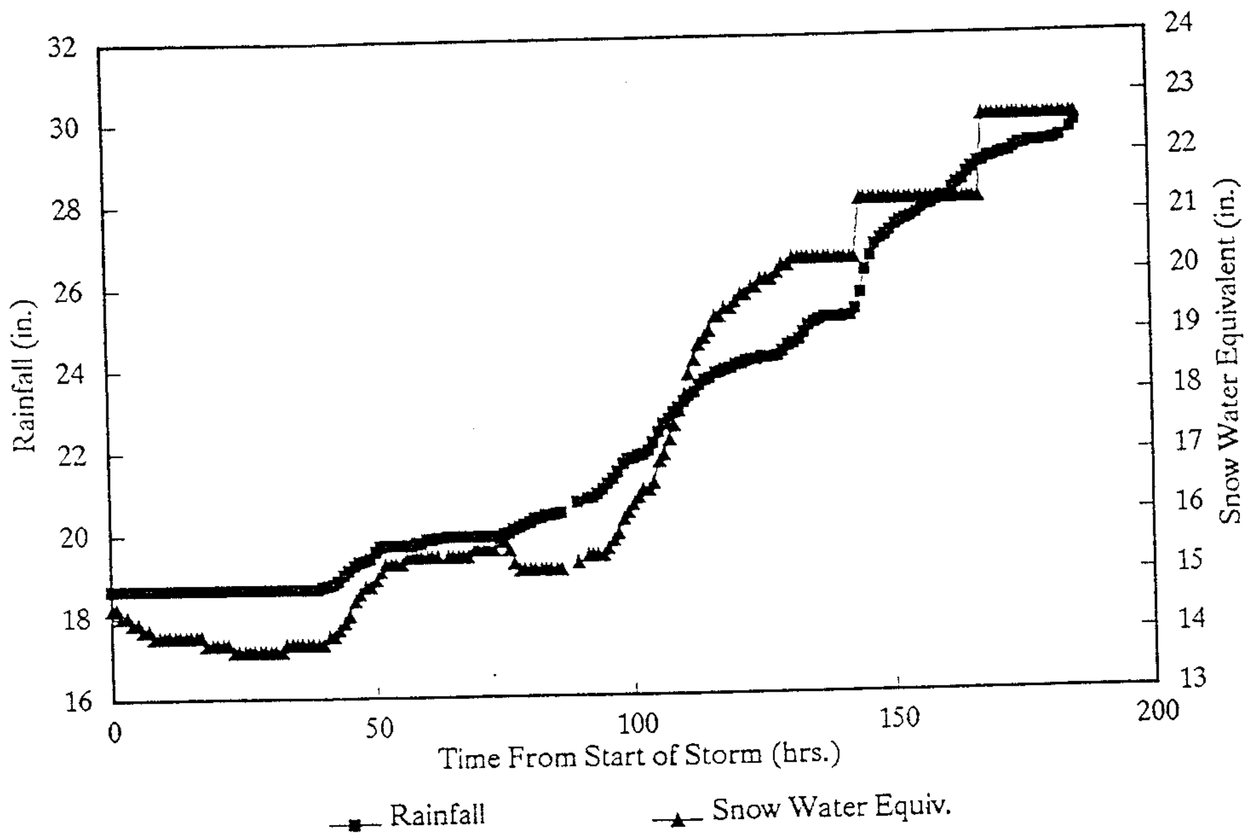


Figure 18. Hourly precipitation data collected at Grizzly Ridge Cal. for the period of February 11 through 20, 1986. Snow water equivalent data from the snow pillow for the last 48 hours are interpolated daily amounts.

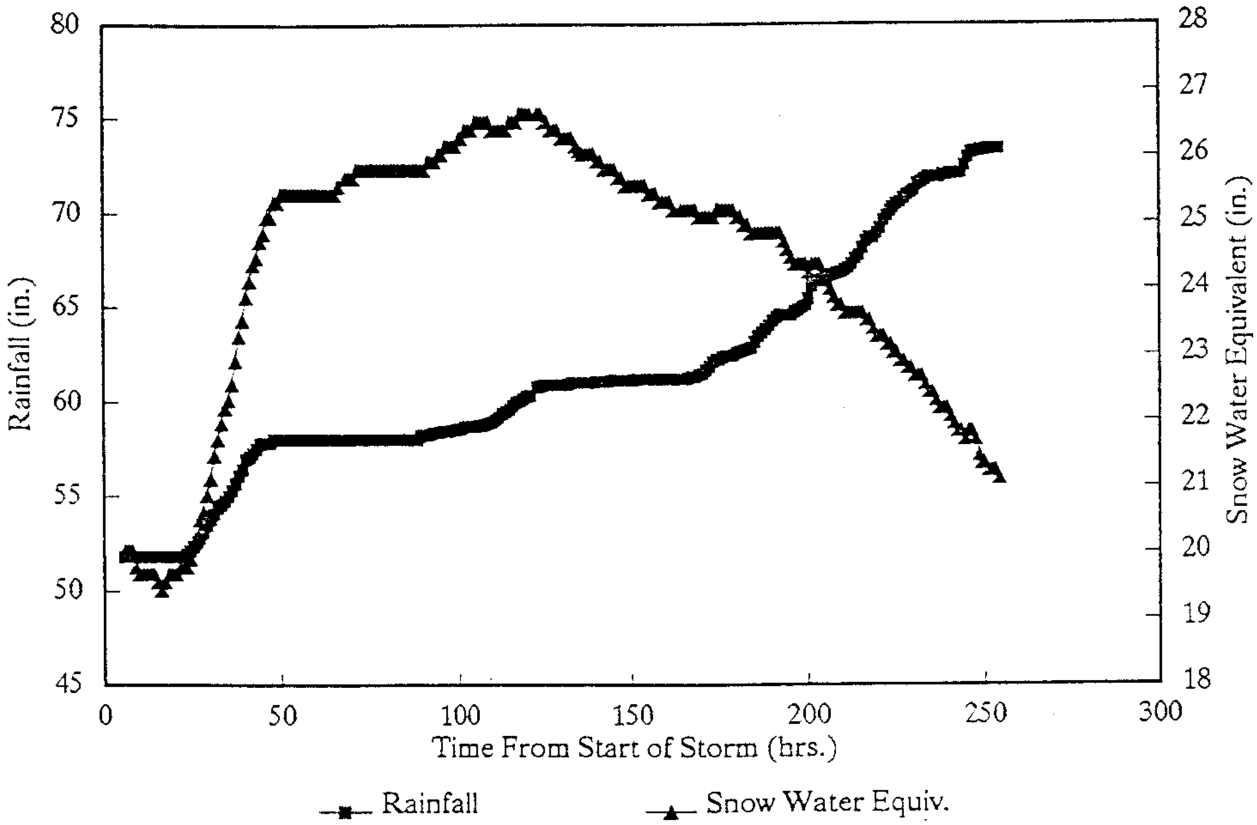


First note that the storm produced about half the precipitation at Gold Lake as occurred at Four Trees. Secondly, the pack retained about half of the precipitation that fell. It is not possible from this data to say that all the precipitation that fell at Gold Lake was rain. However it is fairly certain that from 125 hours to about 160 hours into the storm the precipitation that fell was all rain. During this period the snowpack water equivalent was unchanged even though 12 inches of rain fell. Again, this data substantiates the results of Kattleman that the runoff for a rain on snow event is independent of the snowpack water equivalent and the pack may in fact reduce peak flows by spreading the runoff from the rain over a longer time period.

Figure 18 shows similar data for Grizzly Ridge, a high elevation site on the east edge of the proposed target area. The snowpack water equivalent began at 17 inches, 1.7 inches of which might have been contributed by cloud seeding had it been conducted up to this time. The early part of this storm produced snow and increased the snowpack water equivalent from 17 inches to 19.5 inches water equivalent. During the confirmed rain event (Department of Water Resources staff was working on the Sierra crest during a portion of this period), between 150 and 175 hours, the snow pillow information was unfortunately erroneous as the sensor stuck at 20.3 inches. However, on the 25th the manual snow core measurements were made around the pillow showing 74.8 inches snow depth and 28.5 inches of snowpack water equivalent. Thus Figure 18 shows interpolated daily data rather than hourly data through this period. Daily values were derived based on the rate of precipitation. At this location, the pack apparently gained water throughout the entire storm. Due to the lack of hourly data during a critical time in the storm not much more will be said for this site.

<u>March 1989 Case Study</u> - The second case is for March 1989. Again up to this point in the precipitation season, amounts of snow were well below normal. Thus cloud seeding would have been conducted up to the beginning of this event and most likely have continued through the first 48 hours of the storm given the very dry watershed and low snow levels. During the first 11 days in March of 1989, Four Trees (5,150 feet elevation), had 21.6 inches of precipitation, 6 inches of which fell as snow during March 1 through 2 (Figure 19). The snowpack had a water equivalent of 20 inches on March 1. By March 5 the snowpack water equivalent was 27 inches. Table 14 shows the 24 hours observed rainfall and snowmelt at Four Trees, along with the predicted snowmelt that would be expected based on Figure 15. Note that Figure 15 shows that without any rainfall, a 45 F air temperature for 24 hours will melt 1 inch of water equivalent snowpack. Therefore without any rain at all, had the air temperature remained at 45 F for the five days, 5 inches of water would have been removed. The rain yielded only an additional 1 inch of water from the pack. Also note that it took 24 hours to add 5.44 inches of water to the pack but 5 days to melt it out even with 12.4 inches of rain falling. Thus the pack, although not slowing the rate of rainfall through the pack, did not rapidly contribute the additional water in the pack.

Figure 19. Hourly precipitation measurements made at Four Trees, Cal. for the period of March 1 through 11, 1989.



Assuming seeding had been conducted for all storms up to March 7, as much as 2.7 inches of the maximum water equivalent of 27 inches could have been produced by seeding. As approximately 20 percent of the snowpack water content was removed from the pack during the last 5 days of the storm, seeding might have contributed 20 percent of 2.7 inches or 0.54 inches. This compares to the 12.4 inches of rainfall plus the 4.7 inches of natural snowmelt water equivalent or 0.54/17.1 or a 3 percent contribution from seeding to the total amount of water produced during this event.

Table 14. Observed versus Model Predicted Snowmelt (from Figure 15 at T=45 F)

DATE (Ending Midnight)	24 hr Four Trees Rainfall(in.)	24 hr. Snowmelt Four Trees (in.)	Predicted Snowmelt (in.)
3/07/1989	0.4	0.96	1.00
3/08/1989	1.12	0.36	1.05
3/09/1989	2.76	0.84	1.20
3/10/1989	4.84	1.20	1.45
3/11/1989	3.28	1.32	1.30

For Gold Lake, at 6,750 feet (Figure 20), it started March 1989 with 27.96 inches of snowpack water equivalent. The snowpack water equivalent increased by 4.25 inches (to 32.28 inches) during March 1 to 3, when 6 inches of precipitation fell. Between March 3 and March 11, 13 inches of precipitation fell at Gold Lake. Temperatures were near 40 F. By March 11 the snowpack water equivalent was 31.8 inches or only 0.4 inch below its highest point of the month. Therefore the pack at these elevations contributed almost no additional runoff. Again, any additional water held in the pack due to seeding would also not have been released.

Figure 21 shows data for Grizzly Ridge for the March 1989 event. The increase in snowpack water equivalent during the first 48 hours was due to snow. This 48 hour period would have most likely been seeded. As the snowpack started out with 17 inches of water content, we would assume 10 percent of this might be from seeding or 1.7 inches. Since the next storm would have been seeded we would add an additional 0.25 inch (10 percent of the 2.5 inches which fell). In total, possibly 2 inches of water might have been contributed to the pack up to the 75 hour mark in this event. The major rain on snow event occurred from 175 hours through about 250 hours. The snowpack water equivalent started out at 19.5 inches and ended at 19 inches through this period. Thus the 3.5 inches of rain that fell may have released 0.5 inches of water from the pack over two days. This is only 2.5 percent of the water equivalent in the pack, 10 percent of this is only 0.05 inches contributed from cloud seeding.

Figure 20. Hourly precipitation and temperature data collected at Gold Lake, Cal. for the period of March 1 through 11, 1989.

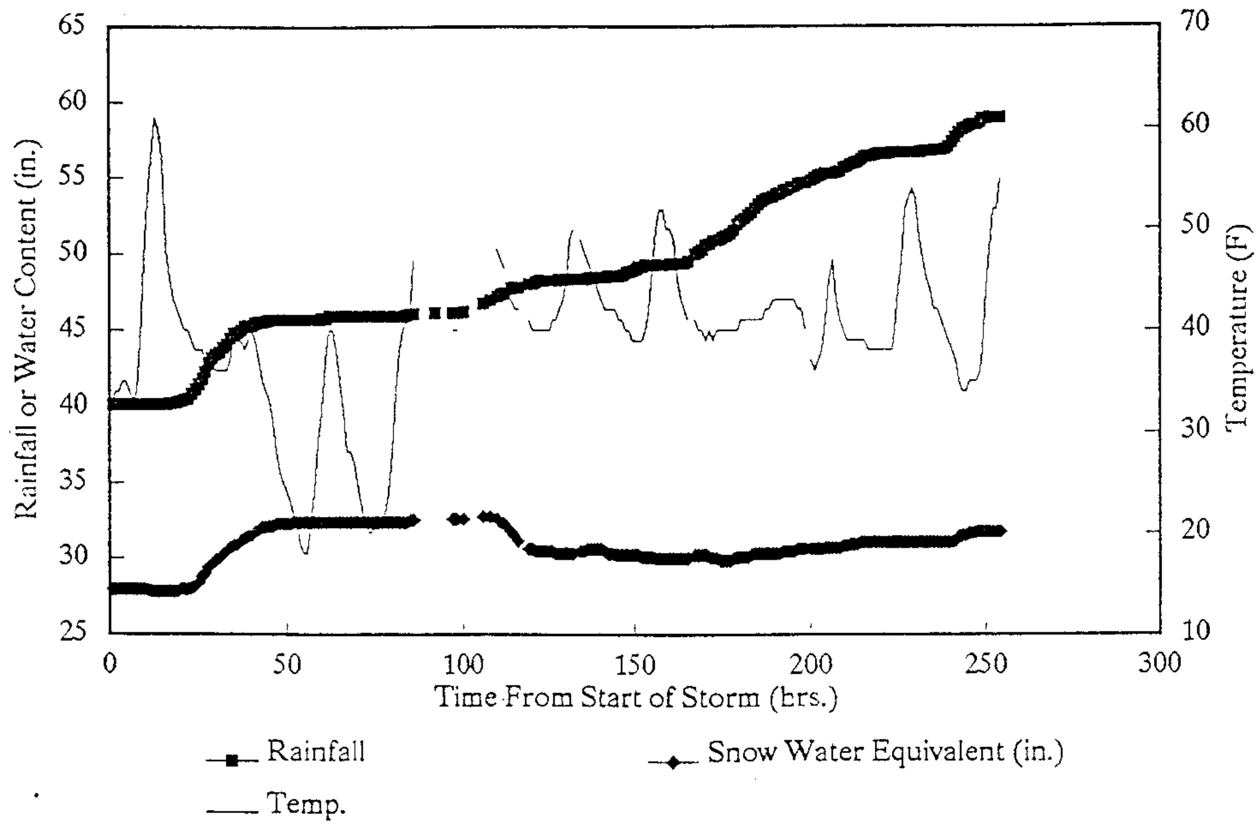
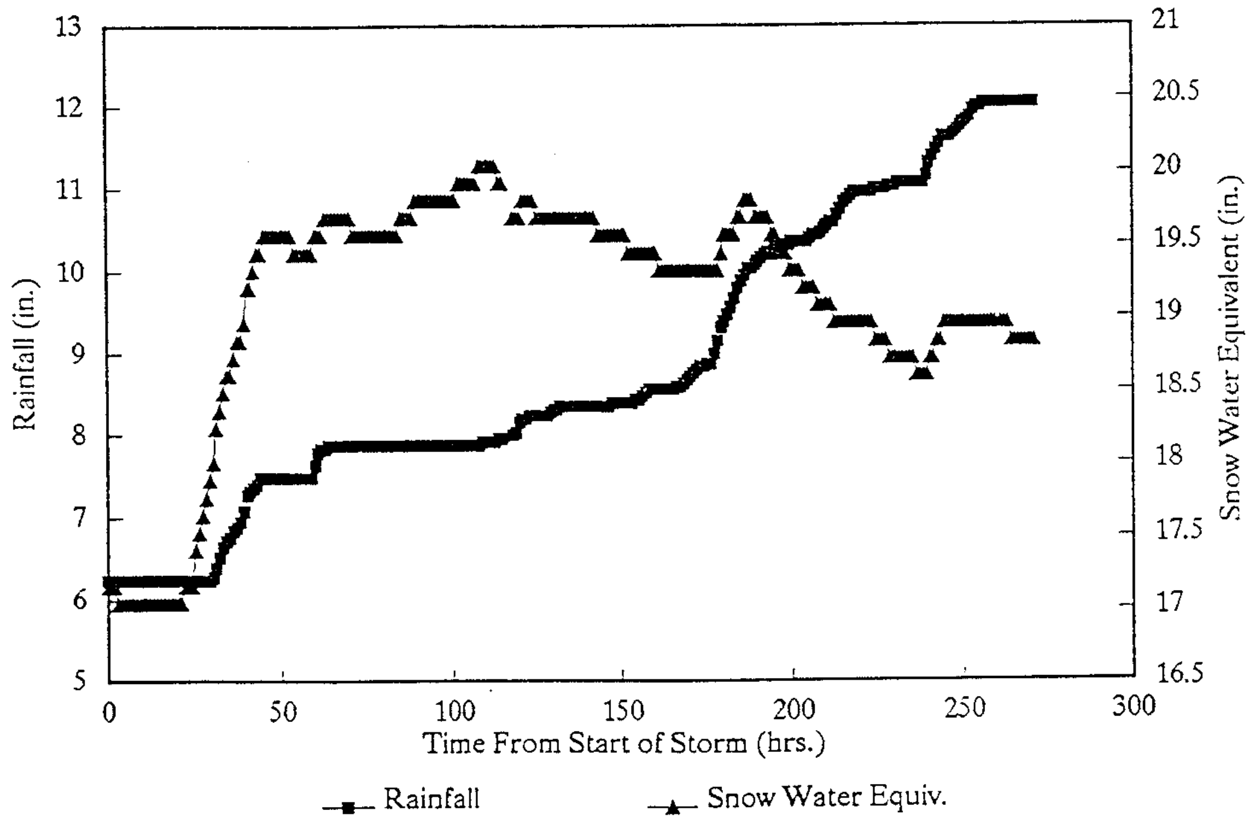


Figure 21. Hourly precipitation data collected at Grizzly Ridge, Cal. for the period March 1 through 11, 1989.



It is apparent that the primary mechanism by which additional water held in the snow from cloud seeding would contribute to runoff and subsequent erosion is if a majority of the snowpack melted. This would only be likely, given the large quantity of rain needed to melt snow, at the low elevations where a fairly shallow and transitory snowpack resides (say from 4,000 to 5,000 feet). As stated on page 48 of the Final EIR/EIS this elevation zone contributes only 15 percent of the target area watershed. In order to quantify this assumption, numerical modelling studies using the March 1989 case were conducted for a representative watershed within the target area.

Hydrologic Modelling Studies

The purpose of this study is to assess the impact of snow added by cloud seeding on the peak streamflow during a rain on snow event in the Feather River basin. Upper Greenhorn Creek, a 10 square mile watershed eight miles east of Quincy, was selected as the study area by the U. S. Forest Service. Of particular interest in this study was snowmelt from the low elevation snow transition zone. The upper Greenhorn Creek watershed ranges from 3,880 to 7,840 feet in elevation, partially within the snow transition zone.

The rain on snow event during March 7 to 11, 1989 was used as the base condition. Precipitation at Quincy during this 96-hour period was 11.9 inches, approximately a 15-year event based on Department of Water Resources depth-duration-frequency data for Quincy from 189 to 1982. As mentioned, a week before this event, a cold storm had brought heavy snow throughout the area. This period provides ideal initial snowpack conditions for this study.

Streamflow hydrographs were developed using the U. S. Corps of Engineer's rain on snow and HEC-1 computer models. The rain on snow procedure performs a water budget analysis that accounts for the water in the snowpack until it is released as runoff. As rain falls on the snow, compaction occurs until the density threshold is reached and runoff from the pack begins. Melt is computed for elevation zones within the basin, based on storm precipitation, temperature, wind and forest cover. Output from the rain on snow procedure combines storm precipitation plus snowmelt and these values are input directly into the HEC-1 model to compute storm hydrographs (Figure 22).

Results from the March 7 to 11, 1989 event indicate that the 10 percent increase in initial snowpack water content assumed for this study from seeding of winter storms has little impact on peak flow as shown by Figure 23. The small incremental increase in snow absorbs a small portion of the precipitation early in the storm and slightly reduces the peak flow by less than 1 percent. Storm hydrographs for the same storm event, but with a shallower initial snowpack were also computed. This condition also showed that a 10 percent increase in snow due to cloud seeding would produce a slight decrease in peak flow.

Figure 22. Combined rainfall and snowmelt output from the U. S. Army Corps. of Engineers rain on snow model both for observed and simulated 50 year event. This information was input to the HEC-1 model to produce hydrographs.

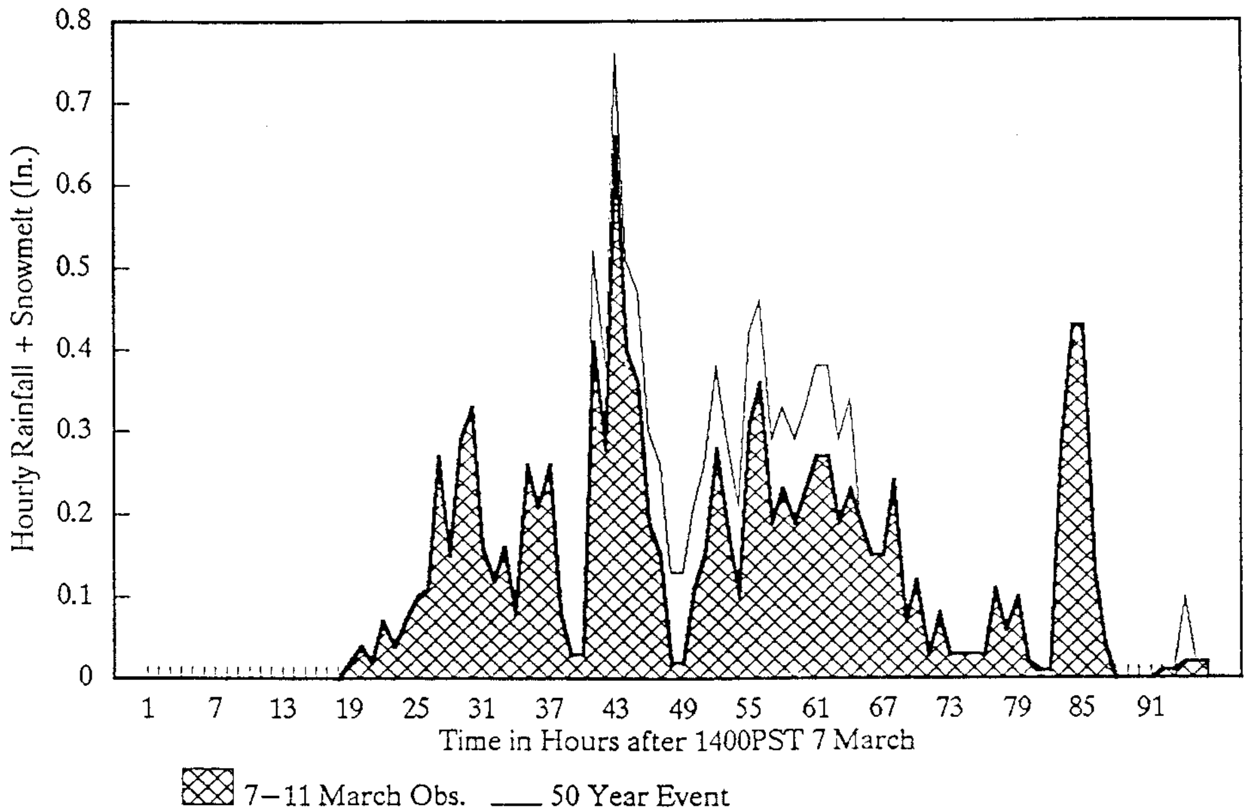
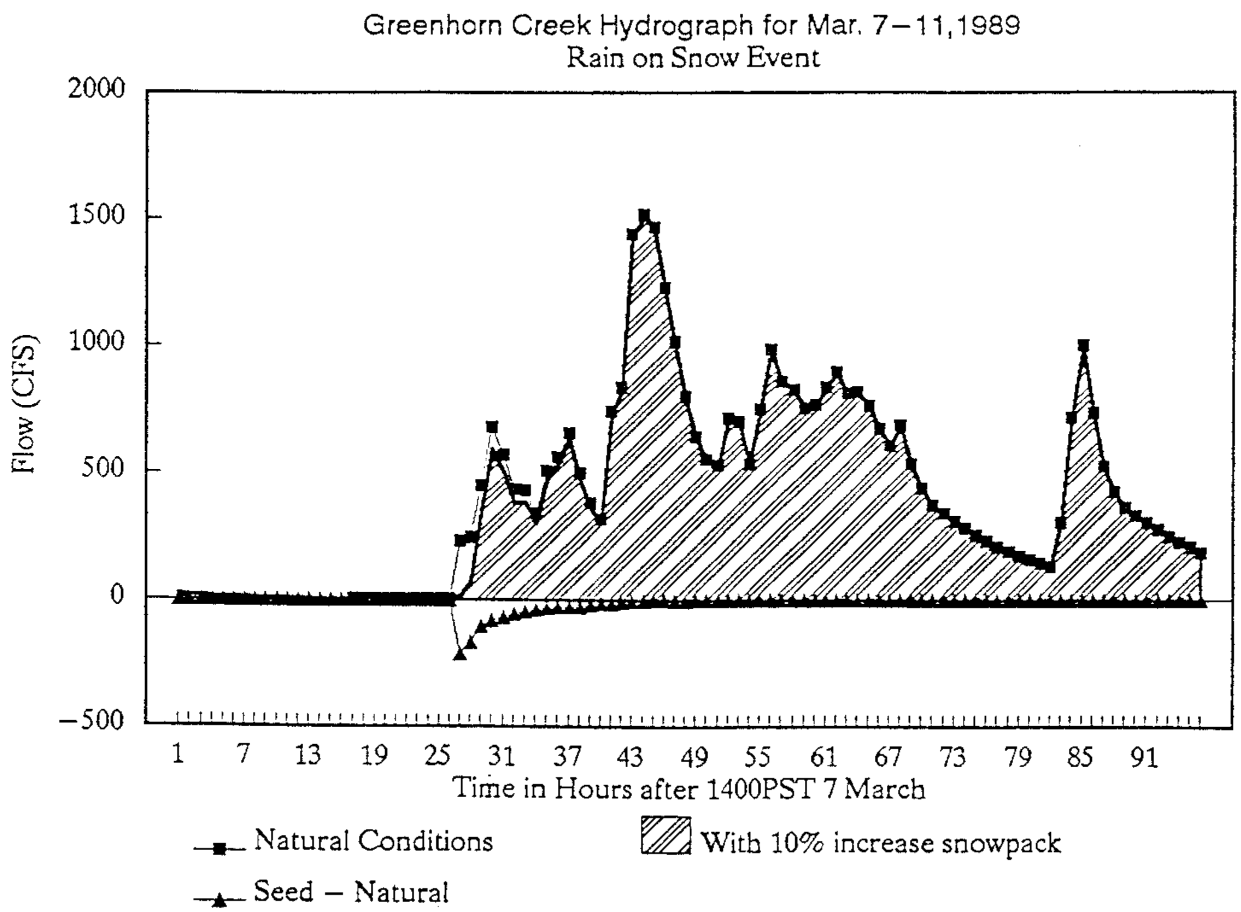


Figure 23. Hydrograph for Greenhorn Creek produced for the observed March 7-11, 1989 rain on snow event. Both the natural runoff and that predicted based on an assumed 10% increase in snowpack are shown.



A 50-year storm event (96-hour total of 14.3 inches of precipitation at Quincy) was also simulated by increasing the precipitation during the heaviest 24-hour period within the March 7 to 11 storm by 0.1 inch per hour (refer back to Figure 22). Hydrographs comparing the effect of additional snow from cloud seeding to the base condition and for a shallow snowpack were also computed for the 50-year storm event. Results for this set of runs also indicate that the additional snow from cloud seeding produces no change in peak flow (Figures 24 and 25).

Greenhorn Creek Rain On Snow Study Model Description

The following discussion provides more detailed information of how the models were set-up.

Rain on Snow Model - The rain on snow procedure used in this study simulates the growth, compaction, and water release from the snowpack during storms that may include periods of both rain and snow. It models snow depth, density, water content and release of melt and rain in response to changing temperatures, precipitation, and wind. The watershed is separated into elevation zones with initial snow conditions specified for each zone. Temperature, wind, and precipitation vary by elevation and melt is computed for each elevation zone. The sum of the rain plus melt from each zone becomes the total rainfall excess for computing the storm hydrograph for the watershed using HEC-1.

The computer source code for this version of the model was developed by the Corps of Engineers Sacramento District. The snow compaction routine was developed by the Bureau of Reclamation. The snowmelt calculations are based on empirical equations that relate wind, temperature, and precipitation to melt. Forest cover and exposure of the watershed are accounted for in the melt equations. The Corps of Engineers uses the rain on snow model to compute probable maximum floods for spillway design and to reconstruct historical flood events. It was used to develop the hydrology for the American River Watershed Investigation draft feasibility report released in April 1991.

For the Greenhorn Creek study the distribution of the watershed area by elevation zone was specified as follows:

Zone (feet)	Area (sq. mi.)
3,888 - 4,000	0.11
4,000 - 5,000	2.26
5,000 - 6,000	2.29
6,000 - 7,000	2.55
7,000 - 7,840	2.74
Total	9.95

A heavy forest cover was assumed for the entire watershed.

Figure 24. Same as Figure 23 only for a simulated 50 year precipitation event.

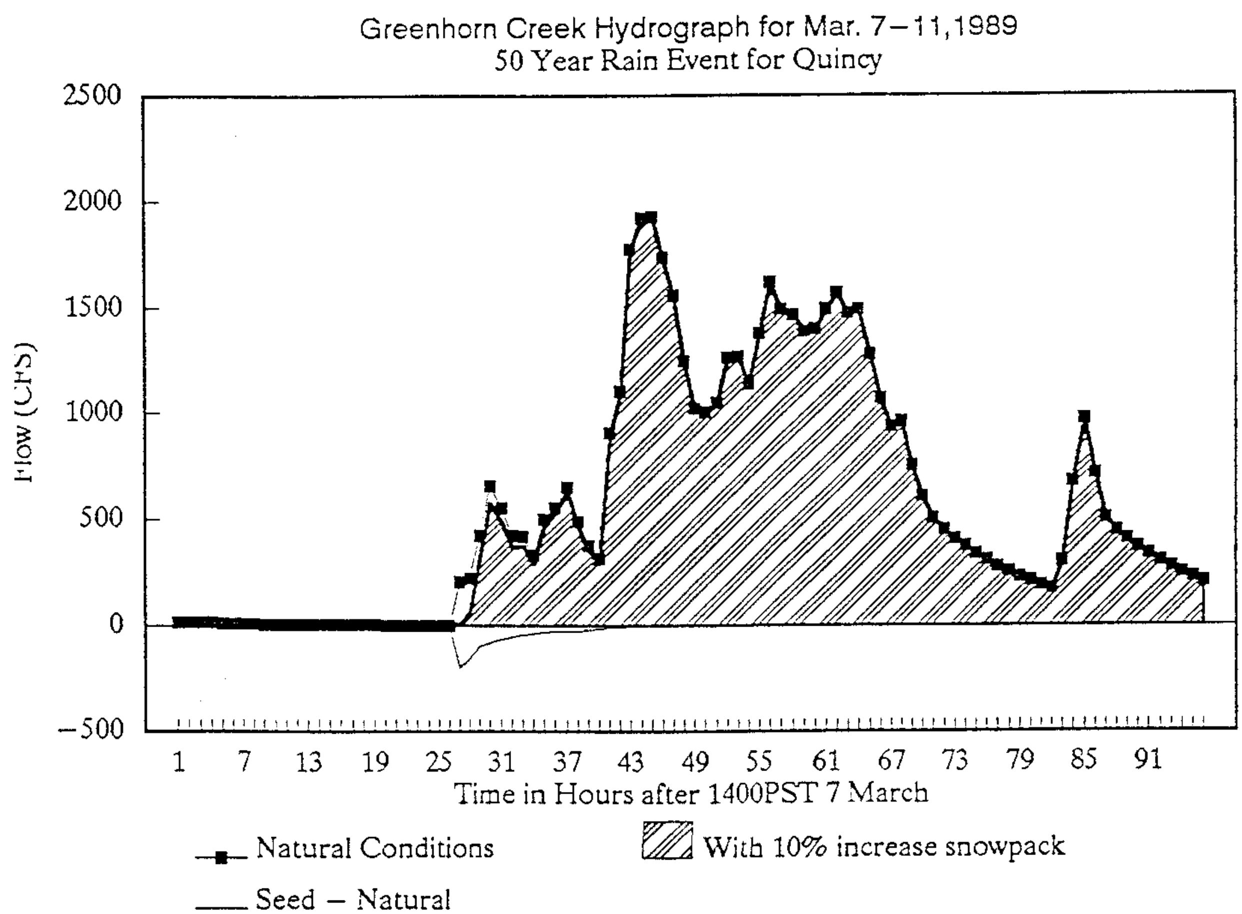
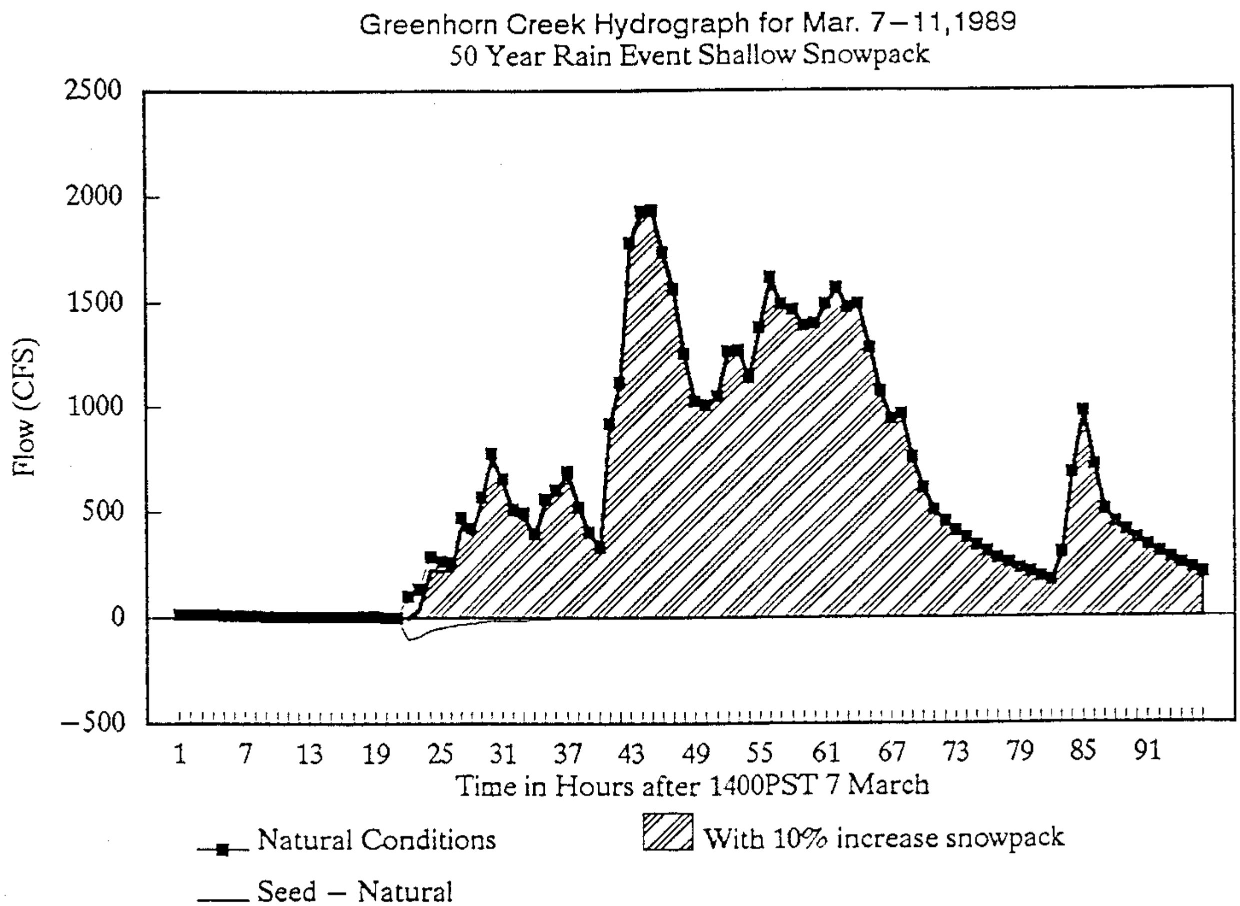


Figure 25. Same as figure 24 but having reduced the snowdepth by 10 inches in the 4,000 to 5,000 foot elevation zone.



Storm data was based on Department of Water Resources telemetered stations: hourly precipitation data at Quincy (elevation 3,400 feet) and 6-hour temperature and wind data at Mills Peak (elevation 7,400 feet). A temperature lapse rate of 1.5 degrees F per 1,000 feet from actual weather balloon profiles during the storm was applied to estimate temperatures for each zone. For this storm, wind at Mills Peak was relatively light and was not reduced at lower elevations (wind lapse rate assumed negligible). Precipitation was assumed to increase with elevation, with the highest elevation zone about 6 percent greater than the 4,000 to 5,000 foot zone.

Initial snow depth and density were estimated from Department of Water Resources snow course and snow sensor data and snowfall reports published in NOAA Climatological Data. The cold storm preceding the rain on snow event deposited substantial depths of snow at low elevations. The snow compacted during the intervening period prior to the rain on snow event. Initial snowpack densities were estimated at 30 percent for the low elevation portion of the watershed, increasing to 38 percent above 7,000 feet. The threshold density at which melt and rain is released from the snowpack was assumed to be 45 percent.

The effect of a greater initial snowpack due to cloud seeding was simulated by adding 10 percent to the initial snow depth and holding snow density constant. The rain on snow simulation showed that a small amount of precipitation early in the storm was absorbed by the incremental increase in snowpack due to cloud seeding, followed by nearly identical patterns of rain plus snowmelt during the remainder of the storm.

Rain on snow simulations were also run to test if a shallower initial snowpack would show a more pronounced effect due to cloud seeding. At the 4,000 to 5,000 foot elevation zone, the base snow condition was reduced from a depth of 22 inches (6.6 inches of water content) to a depth of 12 inches (3.6 inches of water content). Similar scaling was used for the other zones. As before, the comparison run for the cloud seeding case used 10 percent greater snow on the ground as the initial condition. Results from these runs also showed that some rain was absorbed by the incremental increase in snow due to cloud seeding during the early part of the March 7 to 11 storm.

HEC-1 Hydrographs - The computed hourly series of rain plus snowmelt from the rain on snow simulations were input to HEC-1 for with and without cloud seeding scenarios. HEC-1 is the flood hydrograph package developed by the Corps of Engineers Hydrologic Engineering Center. It is widely used to compute storm hydrographs for planning and design.

No observed flow records were available for this study because upper Greenhorn Creek is ungaged. Unit hydrograph ordinates for the watershed were computed from a procedure that uses an S-curve, basin characteristics (slope, distance to center of area, distance of longest watercourse) and a basin roughness factor to relate lag time to basin runoff. An S-curve for the North Fork Feather River was obtained from the Corps of Engineers for this study. The time to peak runoff is slightly less than 1 hour for this watershed, so a computation interval of 1 hour was used in developing storm hydrographs. An initial basin loss value of 0.5 inches (precipitation required before runoff begins) followed by a constant loss rate of 0.1 inch per hour was used for all runs.

The following table shows a slight decrease in peak flow due to cloud seeding with actual snow conditions estimated as of March 7 and no difference in peak flow for a shallow snowpack:

Base Condition	Peak Flow (cfs)
Actual March 7 snow (est.)	1518
Actual March 7 snow + 10% from seeding	1512
Shallow snow	1519
Shallow snow + 10% from seeding	1519

<u>50-year Storm Simulation</u> - The rain on snow and HEC-1 models were also run for a 50-year storm event based on the March 7 to 11 precipitation pattern, but with 2.4 inches of additional precipitation added to the most intense 24-hour period of the storm. The additional precipitation was distributed during this 24-hour period by adding 0.1 inch per hour to the original series. The same initial snowpack conditions were used as described above.

Results for the 50-year storm simulations showed no difference in peak flow due to cloud seeding:

Base Condition	50-year Storm Peak Flow (cfs)
Actual Mar 7 snow (est.)	1929
Actual Mar 7 snow + 10% from seeding	1929
Shallow snow	1929
Shallow snow + 10% from seeding	1929

APPENDIX C - PROTOTYPE CLOUDING MONITORING PROGRAM

The Department of Water Resources and U. S. Forest Service completed a "Joint Environmental Impact Statement-Environmental Impact Report on the Prototype Project to Augment Snowpack by Cloud Seeding Using Ground Based Dispensers in Plumas and Sierra Counties." No adverse effects to the environment were identified nor anticipated from the cloud seeding project. However, concerns for potential water quality degradation, downstream flooding, increased erosion, increased turbidity, and adverse effects to fish, other aquatic life, and sensitive plants from the project have been expressed by area residents. The Department will conduct monitoring in the project area to determine any significant effects from the project on water quality including turbidity, erosion, aquatic life, and sensitive plants.

Monitoring will be conducted during the five-year duration of the prototype cloud seeding project, and following the project for a period of three to five years to provide baseline data for comparison. Consultation with the U. S. Forest Service will be implemented to determine the continuance of the cloud seeding program or other appropriate actions should monitoring detect adverse effects. Methods for data collection will follow standard procedures of the Department of Water Resources, U. S. Forest Service, or widely accepted reference.

Water Quality

Water quality data in the project area is limited. The Middle Fork Feather River is known to suffer degraded water quality due to upstream agricultural activities, but little information is available on the extent of degradation or for tributary streams. Additional data needs to be collected to evaluate water quality conditions in the project area.

Water quality monitoring sites will be established in the project area to assess any effects from the project. The Middle Fork Feather River will be monitored at an upstream and a downstream site in the project area. Monitoring sites will also be established in major tributaries, including Jamison Creek, Nelson Creek, Willow Creek, and Long Valley Creek. Representative stations on these streams will allow monitoring of any water quality effects in the entire upstream drainages. As stated in the U. S. Forest Service Nelson Creek Water Quality Monitoring Plan, water quality monitoring will provide a sensitive tool for assessing impacts of land management practices. Monitoring during the cloud seeding project will provide data on effects from all activities in the watersheds. Post-project monitoring will provide data on effects from activities in the watersheds excluding any produced from cloud seeding. Comparison of project and post-project data will allow determination of any additional effects due to cloud seeding. Exact sampling locations will be determined in consultation with the U. S. Forest Service and field visits.

Monitoring will be conducted approximately monthly beginning during January 1991. Periods of high and low flows will receive emphasis in the monitoring program. High flows selected for monitoring will include the first storm runoff of the season plus at least two additional high runoff events. Any extraordinary events will also be monitored. The period of snowmelt runoff will be included in the monitoring. Parameters to be monitored include suspended sediment, dissolved oxygen, temperature, pH, electrical conductivity, turbidity, alkalinity, organic nitrogen, nitrate nitrogen, and total phosphorus.

Erosion

Numerous sources of erosion exist in the project area, including roads, logged areas, areas damaged by fires, steep unstable slopes, and natural non-point sources. The project is not expected to produce a measurable increase in erosion from these areas. The rate of snowpack melt affects erosion. Snowpack augmentation increases the duration of snowmelt, rather than the rate. Natural annual variation in runoff would also mask any effects which may be attributable to the project.

Little information is available on erosion production from potential sources in the project area. The Department will monitor typical potential erosion sources to determine sediment production.

Monitoring sites will be selected near precipitation gauges so that the relationship between erosion and precipitation may be determined. Since slope aspect may effect precipitation, sites near two precipitation gauges on south facing slopes and two gauges on north facing slopes will be monitored to provide data on erosion production. Areas near the gauges will be field visited to select specific monitoring sites. Sites selected for erosion production monitoring will include roads (cut banks and fill slopes), mountain slopes (burned areas, logged areas, and undisturbed substrate), and stream channels (substrate samples). Sediment production or changes in surface profile will be used to measure erosion from roads and mountain slopes. Substrate samples for particle size distribution will be collected during the summer from stream channels.

Fish and Other Aquatic Life

Streamflows in the project area are subject to large natural fluctuations that affect aquatic life. The project is expected to sustain runoff for a slightly longer period, which may benefit aquatic life, while not contributing significantly to damaging high flows. Effects to aquatic life from the project may not be measurable due to natural population variations. Fish populations, especially, undergo large annual population fluctuations that are often difficult to relate to physical phenomena. Analysis of aquatic habitat provides additional useful data for determining project effects.

Stream cross sections will be established near the water quality monitoring sites for delineation of riffle habitat during the summer. Width and length of pools and riffles, cross-sectional area, water depth and velocity, and surface substrate composition will be documented at each site. A crest-stage gage will be installed to determine stage during sampling.

Benthic macroinvertebrates, as biological indicators of stream conditions, will be monitored during the spring, summer, and fall at each site. Organisms will be identified to genera, where practical, and populations estimated.
Fish will be collected from stream sections near each monitoring site. Fish will be identified to species and estimates made for population sizes. Measurements of length and weight will be obtained for determination of condition factors. The relative abundance of age classes will be determined.

Sensitive Plants

Plant species with extremely limited habitats, including narrow tolerance to soil moisture regimes, may be affected by precipitation augmentation programs that increase soil moisture levels or snowpack duration. The project will augment precipitation during below normal years, while maintaining precipitation within the normal range of variation. Soil moisture levels and snowpack duration are not expected to be altered beyond normal levels by the project.

Effects on sensitive plant populations are not expected. U. S. Forest Service botanists have concluded that it will be difficult, if not impossible, to determine whether cloud seeding affects sensitive plants. The Department, after consultation with botanists with the U. S. Forest Service, developed an extensive plan to monitor Silene invisa. This species is associated with edges of meadows and has specific moisture requirements. Monitoring this species will serve as an indicator of effects from the cloud seeding project. Annual surveys will be conducted to document effects to this indicator species. These studies will be used to determine whether effects to other rare plant populations may occur.

Coordinated Resource Management Program

Data collection activities will assess water quality, biology, and erosion potential in the project area. While providing important background data, these activities do not improve habitat conditions in the watershed. Coordinated Resource Management Programs (CRM) provide coordination of efforts of a variety of governmental agencies and concerned individuals in habitat improvement projects. The Department of Water Resources has been involved in CRM programs in the Feather River drainage, providing assistance to the Red Clover Creek CRM Demonstration Project and contributing to the solution of local problems.
The Department of Water Resources will become a participant to the Jamison Creek CRM, which is currently in the formative stage. As other CRM projects become developed in the Feather River drainage, the Department will participate. Through participation in CRM projects, water quality, biological, and erosional problems can

be identified and resolved.

APPENDIX D - SUPPLEMENTAL INFORMATION FOR THE EIS

Some of the information provided in the Final EIR/EIS is no longer current. The following discussion updates the information provided in the EIR/EIS.

Retirements and personnel transfers require updating of the information provided on the title sheet (page i) of the Final EIR/EIS. Mary Coulombe is no longer with the Plumas National Forest. John Palmer is the current acting Forest Supervisor. Larry Mullnix has retired from the Department of Water Resources and his position is currently vacant, though John Silveira is acting Deputy Director. Richard Lallatin has also retired from the Department and has been replaced as project manager by Jerry Boles at the same address.

The Opportunities section (page 7, number 1) has been expanded to reflect the requirements of the current monitoring program and should read: Collect water quality, sediment, aquatic invertebrate, fish population and erosion data within the project area. The collection of additional streamflow information was not a component of the monitoring plan and should be dropped from item number 3.

At the time the Final EIR/EIS was prepared, the Department had not identified a storage area for the off-season storage of the propane tanks. The tanks will be stored on the Soper-Wheeler property within T22N, R12E, Section 7. Installation and removal of the tanks will be staged out of this site rather than the Johnsville ski area parking lot. An amended flight path is displayed in Figure 26, which was Figure 4 in the Final EIR/EIS. The Soper-Wheeler property is east of Johnsville and the helicopter flight path will be over the remote largely uninhabited area to the east of Johnsville and then south to the dispenser sites. Overflight of residences will be avoided.

Eight, not nine, precipitation gauging stations will be installed. Their locations are shown in Figure 27, which was Figure 7 in the Final EIR/EIS. Legal descriptions of these updated locations are as follows:

Station	Location	Remarks
1	T22N-R11E-Sec 24 SE 1/4 - NW 1/4	Located on Plumas-Eureka State Park property adjacent to existing non-automatic recording gauge. Approximate elevation - 5,200 ft.
2	T22N-R13E-Sec 33 NW 1/4 - NE 1/4	Located on land owned by USFS. The archaeological and plant survey indicated no adverse impact or disturbance by installation of gauge.
3	T23N-R12E-Sec 33 NW 1/4 - NW 1/4	Located on USFS land, accessible using USFS Road 23N06. Archaeol-

		ogical and plant surveys indicate no adverse impact or disturbance by installation of gauge.
4	T23N-R12E-Sec 26 NW 1/4 - SE 1.4	This gauge has been installed on private property. The archaeol-ogical and plant survey reported no impact or disturbance by installation of gauge.
5	T23N-R12E-Sec 36 SW 1/4 - NE 1/4	Located on USFS land, accessible using USFS Road 22N04. Archaeol-ogical and plant surveys indicate no adverse impact or disturbance by installation of gauge.
6	T23N-R12E-Sec 16 NE 1/4 - SE 1/4	This gauge will be installed on private property. Archaeological and plant survey reported there was no impact or disturbance by installation of gauge.
7	T23N-R13E-Sec 17 NE 1/4 - SE 1/4	Located on USFS land, accessible by using USFS Road 24N07. Archaeol-ogical and plant surveys indicate no adverse impact or disturbance by installation of gauge.
8 1/4 - NW 1/4	T21N-R12E-Sec 2	Located on USFS land, accessible by SE using USFS Road 22N98. Archaeol-ogical and plant surveys indicate no adverse impact or disturbance by installation of gauge.

In the discussion of wildlife species occurrence in the project area on page 35 of the Final EIR/EIS, beaver should be deleted as a "game" species.

The <u>Erosion</u> subsection on page 51, although technically correct, could be rewritten to provide more site specific information. The first paragraph could read: U.S. Forest Service soils data indicate that soil having high to very high erosion hazard potential occur in nearly every watershed within the project area. The area occupied by soils of high to very high erosion potential in each watersheds range from 0 to nearly 63 percent. Landslides, the major geomorphic stability problem in the project area have been identified in nearly all the watersheds in the project area. The second paragraph would be unchanged.

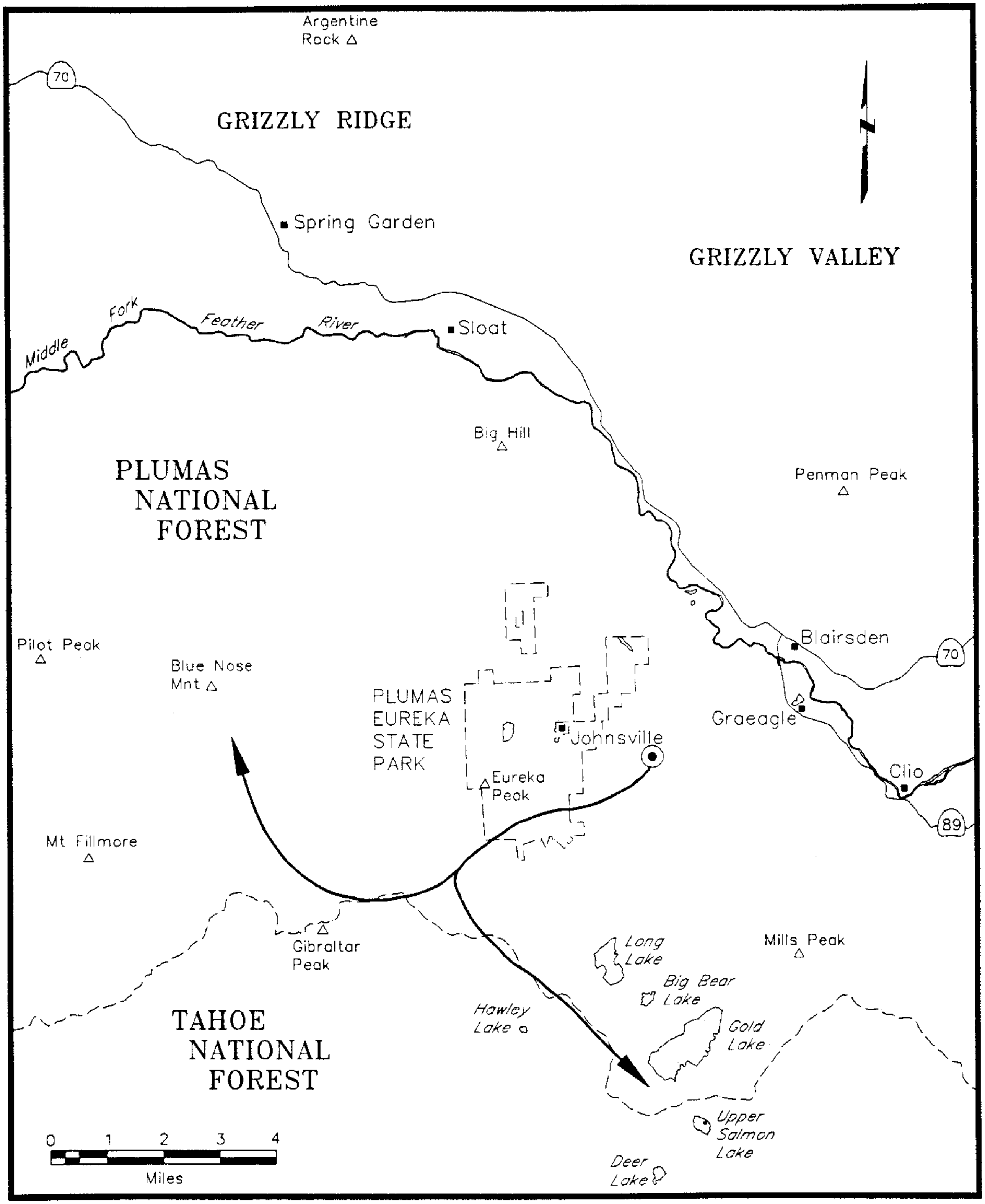


Figure 26. Flight path for Moving Propane Tanks From Staging Area to Dispenser Sites

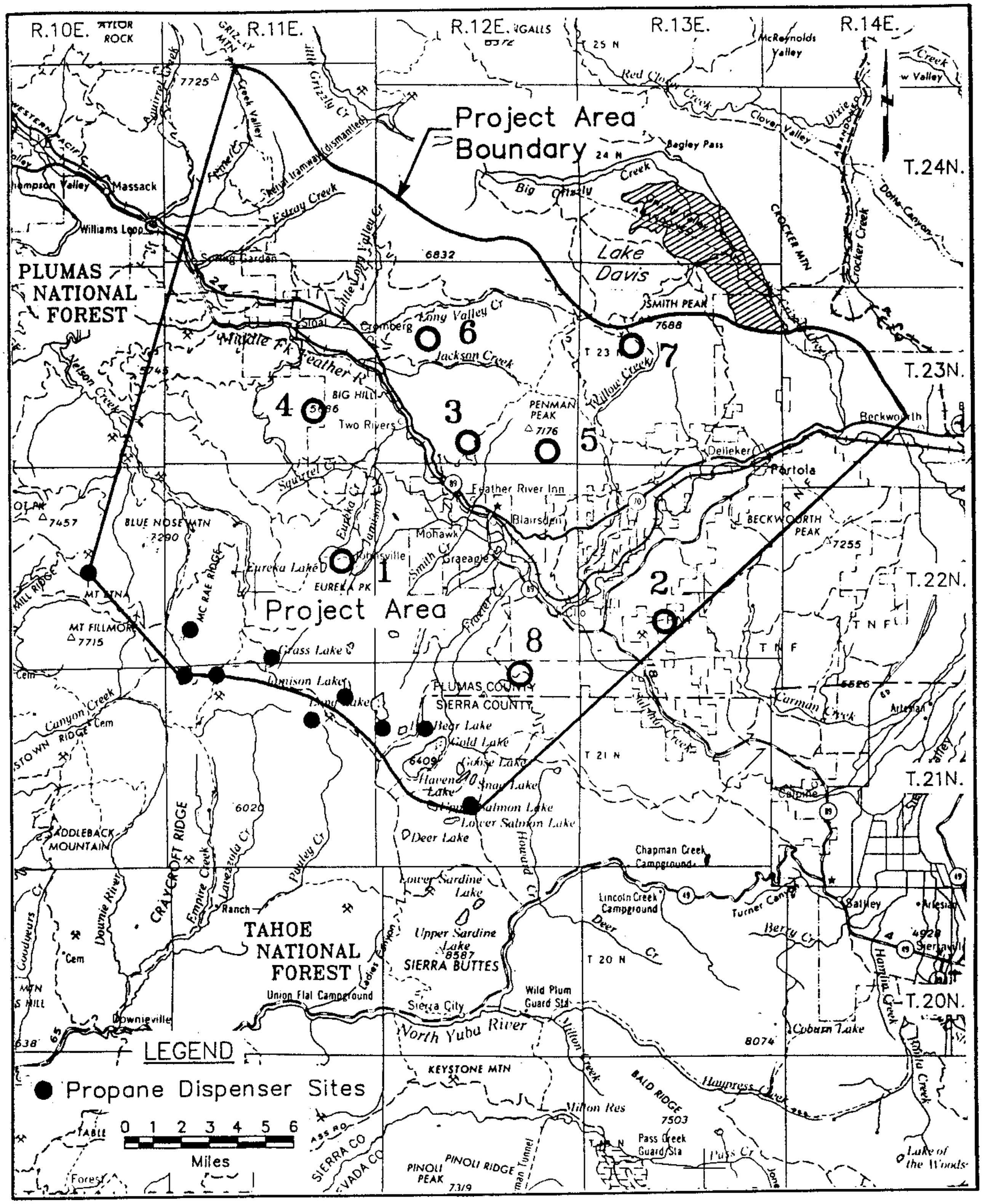


Figure 27. Approximate Precipitation Gauge Locations.

In the Endangered and Threatened Animals section (page 59), the following corrections should be added to Table 1:

U.S. = U.S. Fish and Wildlife Service
F.S. = Forest Service
State = California Department of Fish and Game

Species	Listing Status
Bald Eagle	U.S.-Endangered, State-Endangered
Golden Eagle	F.S.-Sensitive, State-Special concern, U.S.-Protected
Prairie Falcon	State-Special concern
Northern Goshawk	F.S.-Sensitive, State-Special concern
Spotted Owl	F.S.-Sensitive, State-Special concern U.S. Candidate
Short -Eared Owl	State-Special concern
Willow Flycatcher	F.S.-Sensitive, State-Special concern
Sierra Nevada Red Fox	U.S.-Candidate, State-Threatened F.S.-Sensitive
Wolverine	U.S.-Candidate, State-Threatened
Pine Marten	F.S.-Sensitive

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